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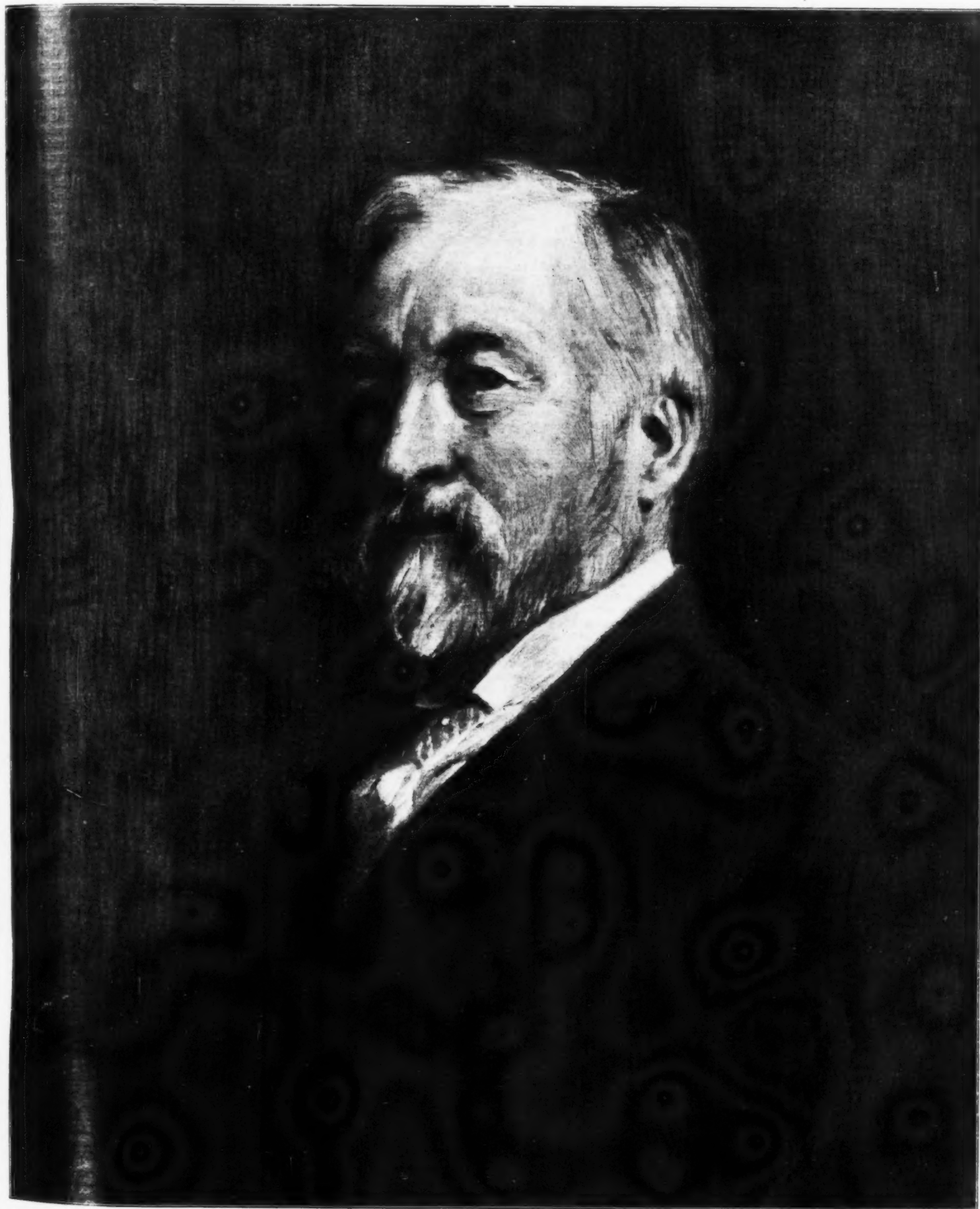
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S. P. Langley

After a painting by Robert Gordon Hardie.

THE LATE SAMUEL PIERPONT LANGLEY.

SAMUEL PIERPONT LANGLEY, secretary of the Smithsonian Institution, one of the world's greatest scientists, died on February 27, 1906.

It is safe to say that no just estimate of the very eminent and useful pioneers of the physical sciences for the past several decades would fail to include Samuel Pierpont Langley.

Born in Roxbury, Mass., August 22, 1834, Mr. Langley was graduated from the Boston High School in 1851, thereafter took up the study of civil engineering and architecture, and subsequently practised these professions, furnishing an instance of a certain tendency among men of attainment to believe in and utilize a minor talent in the beginning as the working field for a career. But his interest in astronomy was innate, and the time saved from the demands of engineering and architecture went to the study of that science. Parts of the years 1864 and 1865 he spent in European travel, visiting foreign observatories and learned institutions, to return bent upon devoting his life to scientific pursuits. The practice of architecture had imbued him with a keen aesthetic sense and powerful constructive imagination. No one better enjoyed the beautiful solution of a problem. This fine sense of proportion, but more especially the faculty of creative imagination, modern astronomy and physics both demand as the working basis for success.

In 1865 he became an assistant at the Harvard College Observatory, and the following year was appointed Assistant Professor of Mathematics in the United States Naval Academy at Annapolis. Within the same year he became the director of the new Allegheny Observatory at Pittsburg.

It was here that he found opportunity for one of the few directly utilitarian services ever rendered by astronomy—the establishment in connection with the Pennsylvania Railroad Company's telegraphs, of the now familiar system of the standard time service by telegraphic signals. At that time (1868) the use of local times was universal in this country, even by the railways, and confusion or accident was frequent and inevitable. By these signals this confusion was stopped over the whole area from the Atlantic seaboard to the Great Lakes. The system was at once widely imitated.

Mr. Langley's interest in pure astronomy was now rapidly developing into a greater interest in astrophysics, and he began the well-known series of researches upon the sun and the physics of the solar radiation with which his name has been most intimately associated. In 1869, in 1870, and in 1878 he had charge of government eclipse expeditions, of which the last, to Pike's Peak, resulted in determining a hitherto unsuspected extent of the corona. His work upon sun spots, extending over this period, is too well known to need mention here, except to call attention to the remarkable accuracy of observation, as well as the skill of draftsmanship, which renders his drawings of sun-spot phenomena made before the days of solar photography, perhaps the final statement of what the eye can see of the surface of the sun.

About 1875 he began to devote much attention to the heat spectra of the sun and other hot bodies, and as an aid to that research he in 1880 devised the bolometer, probably the most useful and delicate instrument for the measurement of radiation.

To this period, and as part of the general research upon the sun's physical relation to the earth, belong the important preliminary papers on the energy spectrum of the sun, the transmission of the earth's atmosphere, on the Solar Constant, the behavior of prisms toward radiations of long wave-length from bodies at low temperatures, the energy-spectra of heated terrestrial objects, and the energy spectrum of the moon. The moon's heat had hitherto been barely recognized by the thermopile, but with the bolometer Mr. Langley was able to analyze minutely the details of its spectrum.

During these researches at Allegheny he had become convinced that there was a great, and then unsuspected, selective absorption of the sun's energy both in the sun's and the earth's atmosphere. Again successful in obtaining the aid of the government, he organized in 1881 an expedition to the top of Mount Whitney, in California, the abrupt heights of that lofty peak permitting observations to be made from two stations geographically close together, but separated by more than two miles of altitude. The result of the observations made became the basis for an entire change in the hitherto accepted value of the Solar Constant, as determined by Pouillet's methods, and the reversal of the old belief that the atmospheric absorption was greatest in the red end of the spectrum.

Mr. Langley was now fairly embarked upon a monumental task, not yet fully completed, requiring unusual niceties of observation and deduction. This was the exploration and mapping of the great unknown region of the solar spectrum lying beyond the visible red light, and in which region fall the wave-lengths of the far greater part of the heat-energy lavished upon the solar system. To the study of the visible spectrum the science of chemistry is under a vast debt, and upon it is largely founded all modern knowledge of stellar systems other than our own. Photography had revealed the invisible region beyond the violet, but wave-lengths of only one-tenth the range he had by 1885 demonstrated to exist were under study by these means.

In 1887, at the beginning of this research, Mr. Langley became secretary of the Smithsonian Institution, which officially represents the interests of the United States in pure science.

It is here that Mr. Langley has most conspicuously

shown the characteristics which had early marked him for an eminent career. Without an executive intelligence of a high order, the workings of the institution must have suffered a decline from the high plane of usefulness inaugurated for it by Prof. Joseph Henry and carried on by Prof. S. F. Baird, whose administration had preceded Mr. Langley's. The institution has expanded in all of its activities under his charge, and his fitness to control a complex system of subordinate bureaus and men has been salient. As the head of the institution, his ability to present to Congress the needs of the sciences in this country has been of great service, and it is due largely to his efforts that the institution also administers private appropriations for scientific purposes, and has attracted large bequests to be devoted to similar ends.

These duties have necessarily occupied much of his time, but he has continued to give his personal direction to the Astrophysical Observatory, which has been most steadily engaged in the investigation of the infra-red spectrum. Here also were carried out a series of comparisons (with the bolometer) of the heat-energy emitted by various natural and artificial sources of light, with that of fire-flies and glow-worms, to demonstrate their relative efficiencies. It was here that, in 1892, the instrumental equipment was brought to include the automatic mechanism whereby the relative movement of the bolometer in the spectrum, and of a photographic plate past the beam of light reflected from the mirror of the galvanometer, were very accurately related, so that the infra-red spectrum could be quickly explored, and a photographic image of its energy-curve recorded. Much valuable minor research in optical physics, as well as in instrumental design, has been here accomplished. Mr. Langley directed a very completely equipped expedition from this observatory to Wadesboro, N. C., for the observation of the eclipse in 1900, which resulted in an interesting determination of a value for the radiation from the corona, and some very remarkable photographic observations.

After Mr. Langley became the head of the Smithsonian Institution, he was enabled to begin that series of efforts to solve one of the greatest of human problems—that of mechanical flight—which has lately attracted such widespread popular interest in this country. His interest in flight dates from boyhood, and it has long been his belief that the true course for the solution of this problem lies initially in the result of a research into the conditions surrounding the behavior of heavy bodies in motion through the air, rather than in immediate experimental attempts at flight. It has been his aim then, in inaugurating any work whatever in this direction, to establish, first of all, with such accuracy as the resources of refined physical measurement and diligent experiment could produce, the conditions which would surround the final mechanical solution. He took up the subject seriously in 1889, and in 1891 published his "Experiments in Aerodynamics,"* and later, after unceasing experiment, he was enabled to print the larger theory in a paper entitled "The Internal Work of the Wind."† This preliminary work satisfied him of the possibilities of mechanical flight, and under the great discouragements of what will perhaps ultimately be recognized as the most difficult branch of mechanical engineering, he commenced and for several years carried on the actual construction of experimental flying machines based upon the principles which had been developed in his private workshop at the institution. In 1896, for the first time in history, a mechanical structure, free of any attachment to the ground and wholly without any supporting power but its own engines, made several flights of over one-half mile each. Mr. Langley had at this point reached the original aim of his researches in this direction—that of demonstrating, as a question of mechanical engineering, first, the conditions for, and second, the possibility of accomplishing, mechanical flight. It was only later, the necessities of the military branch of the government indicating the need of a demonstration of the practical possibilities of flight, that Mr. Langley determined to go on with those experiments, which are so well known to the newspaper-reading public, and which have so far brought only negative results. It may be said in passing that it requires moral courage of a high order for a man already secure in popular estimation as a savant to attempt to build a flying machine, since the effort is sure of ridicule by a large section of the unthinking public, which sees no merit save in absolute success.

It is difficult to speak of Mr. Langley apart from his work. The two are inseparable. Yet the aesthetic sense mentioned as one of his chief characteristics finds outlet in a very wide reading, by no means confined to scientific literature. Added to his capacity to recuperate from the cares of his work by travel, which is perhaps his chief amusement, Mr. Langley is a member of the Metropolitan and Cosmos clubs in Washington, of the Metropolitan and Century clubs in New York, and of the St. Botolph Club in Boston, and may frequently be found at one or the other of their houses, or enjoying the game of golf at some country club.

Foreign institutions and scientific bodies have showered upon him degrees and honors. He has received the degrees, D.C.L., of Oxford; D.Sc., of Cambridge; is a foreign member of the Royal Society of Great Britain, correspondent of the Academy of Sciences, Institute of France, and Fellow of the Royal Astronomical Society, and Member of the Royal Institution; he has been awarded the Janssen medal by the Institute of France, and the medal of the Scientific Society

of France, and the Rumford medal by the Royal Society of London; while at home the universities of Harvard, Princeton, Michigan, and Wisconsin have given him the degree of LL.D. He was president of the American Association for the Advancement of Science (1887), and has been awarded the Henry Draper medal and the Rumford medal by the National Academy of Sciences of the United States, of which body he is a member.

Mr. Langley's published writings include over one hundred titles. It was not the least of his important qualifications as an investigator, that he wrote with conspicuous clearness and in an English style which enlivened the driest statement.

GOLD AND ITS CHEMISTRY.*

By G. T. BEILBY.

IN scanning the list of the elements with which we are thoughtfully supplied every year by the International Committee on Atomic Weights, the direction in which our thoughts are led will depend on the particular aspect of chemical study which happens to interest us at the time. Putting from our minds on the present occasion the attractive speculations on atomic constitution and disintegration with which we have all become at least superficially familiar during the past few years, let us try to scan this list from the point of view of the "plain man" rather than from that of the expert chemist. Even a rudimentary knowledge will be sufficient to enable our "plain man" to divide the elements broadly into two groups—the actually useful and the doubtfully useful or useless. Without going into detail we may take it that about two-thirds would be admitted into the first group, and one-third into the second. It must be regarded as a very remarkable fact that of the eighty elements which have had the intrinsic stability to enable them to survive the prodigious forces which must have been concerned in the evolution of the physical universe, so large a proportion are endowed with characteristic properties which could ill have been spared either from the laboratories of Nature or from those of the arts and sciences. Even if one-third of the elements are to be regarded as waste products or failures, there is here no counterpart to the reckless prodigality of Nature in the processes of organic evolution.

If we exclude those elements which participate directly and indirectly in the structure and functions of the organic world, there are two elements which stand out conspicuously because of the supreme influence they have exercised over the trend of human effort and ambition. I refer, of course, to the metals gold and iron.

From the early beginnings of civilization gold has been highly prized and eagerly sought after. Human life has been freely sacrificed in its acquirement from natural sources, as well as in its forcible seizure from those who already possessed it. The "Age of Gold" was not necessarily "The Golden Age," for the noble metal in its unique and barbaric splendor has symbolized much that has been unworthy in national and individual aims and ideals.

We have accustomed ourselves to think of the present as the Age of Iron, as indeed it is, for we see in the dull, gray metal the plastic medium out of which the engineer has modeled the machines and structures which play so large a part in the active life of to-day. Had iron not been at once plentiful and cheap, had it not brought into the hands of the engineer and artificer its marvelous qualities of hardness and softness, of rigidity and toughness, and to the electrician its mysterious and unique magnetic qualities, it is not difficult to conceive that man's control over the forces of Nature might have been delayed for centuries, or perhaps for ages. For iron has been man's chief material instrument in the conquest of Nature; without it the energy alike of the waterfall and of the coalfield would have remained uncontrolled and unused. In this conquest of the resources of Nature for the service of man are we not entitled to say that the intellectual and social gains have equaled, if they have not exceeded, in value the purely material gains; and may we not then regard iron as the symbol of a beneficent conquest of Nature?

With the advent of the Industrial Age gold was destined to take a new place in the world's history as the great medium of exchange, the great promoter of industry and commerce. While individual gain still remained the propelling power toward its discovery and acquisition, every fresh discovery led directly or indirectly to the freer interchange of the products of industry, and thus reacted favorably on the industrial and social conditions of the time.

So long as the chief supplies of gold were obtained from alluvial deposits by the simple process of washing, the winning of gold almost necessarily continued to be pursued by individuals, or by small groups of workers, who were mainly attracted by the highly speculative nature of the occupation. These workers endured the greatest hardships and ran the most serious personal risks, drawn on from day to day by the hope that some special stroke of good fortune would be theirs. This condition prevailed also in fields in which the reef gold occurred near the surface, where it was easily accessible without costly mining appliances, and where the precious metal was loosely associated with a weathered matrix. These free-milling ores could be readily handled by crushing and amalgamation with mercury, so that here also no elaborate organization and no great expenditure of capital were necessary. A third stage was reached when the more easily worked

* Smithsonian Publication No. 301.

† Smithsonian Publication No. 384.

* Abstracted from an address delivered before the South African meeting of the British Association for the Advancement of Science.

deposits above the water-line had been worked out. Not only were more costly appliances and more elaborately organized efforts required to bring the ore to the surface, but the ore when obtained contained less of its gold in the easily recovered, and more in the refractory or combined form. The problem of recovery had now to be attacked by improved mechanical and chemical methods. The sulphides or tellurides with which the gold was associated or combined had to be reduced to a state of minute subdivision by more perfect stamping or grinding, and elaborate precautions were necessary to insure metallic contact between the particles of gold and the solvent mercury. In many cases the amalgamation process failed to extract more than a very moderate proportion of the gold, and the quartz sand or "tailings" which still contained the remainder found its way into creeks and rivers or remained in heaps on the ground around the batteries. In neighborhoods where fuel was available a preliminary roasting of the ore was resorted to, to oxidize or volatilize the baser metals and set free the gold; or the sulphides, tellurides, etc., were concentrated by washing, and the concentrates were taken to smelting or chlorinating works in some favorable situation where the more elaborate metallurgical methods could be economically applied. Many efforts were also made to apply the solvent action of chlorine directly to the unconcentrated unroasted ores; but unfortunately chlorine is an excellent solvent for other substances besides gold, and in practice it was found that its solvent energy was mainly exercised on the base metals and metalloids, and on the materials of which the apparatus itself was constructed.

This to the best of my knowledge is a correct, if rather sketchy, description of the state of matters in 1889, when the use of a dilute solution of cyanide of potassium was first seriously proposed for the extraction of gold from its ores. Those of us who can recall the time will remember that the proposal was far from favorably regarded from a chemical point of view. The cost of the reagent, its extremely poisonous nature, the instability of its solutions, its slow action—such were the difficulties that naturally presented themselves to our minds. And, even granting that these difficulties might be overcome, there still remained the serious problem of how to recover the gold in metallic form from the extremely dilute solutions of the cyanide of gold and potassium. How each and all of these difficulties have been swept aside, how within little more than a decade this method of gold extraction has spread over the gold-producing countries of the world, now absorbing and now replacing the older processes, but ever carrying all before it—all this is already a twice-told tale which I should feel hardly justified in alluding to were it not for the fact that we are to-day meeting on the Rand where the infant process made its *début* nearly fourteen years ago. The Rand to-day is the richest of the world's goldfields, not only in its present capacity, but in its potentialities for the future; twenty years ago its wonderful possibilities were quite unsuspected even by experts.

It is not for me to describe in detail how the change has been accomplished; this task will, we know, be far better accomplished by representative chemists who are now actively engaged in the work. But for the chemists of the British Association it is a fact of great significance that they are here in the presence of the most truly industrial development of gold production which the world has yet seen; a development moreover that is founded on a purely chemical process which for its continuance requires, not only skilled chemists to superintend its operation, but equally skilled chemists to supply the reagent on which the industry depends.

In 1889 the world's consumption of cyanide of potassium did not exceed fifty tons per annum. This was produced by melting ferrocyanide with carbonate of potassium, the clear fused cyanide so obtained being decanted from the carbide of iron which had separated. The resulting salt was a mixture of cyanide, cyanate, and carbonate which was sometimes called cyanide of potassium for the hardly sufficient reason that it contained 30 per cent of that salt. When the demand for gold extraction arose, it was at first entirely met by this process, the requisite ferrocyanide being obtained by the old fusion process from the nitrogen of horns, leather, etc. In 1891 the first successful process for the synthetic production of cyanide without the intervention of ferrocyanide was perfected, and the increasing demand from the gold mines was largely met by its use. At present the entire consumption of cyanide is not much short of 10,000 tons a year, of which the Transvaal goldfield consumes about one-third. Large cyanide works exist in Great Britain, Germany, France, and America, so that a steady and sure supply of the reagent has been amply provided. In 1894 the price of cyanide in the Transvaal was 2s. per pound; to-day it is one-third of that, or 8d. During the prevalence of the high prices of earlier years the manufacture was a highly speculative one, and new processes appeared and disappeared with surprising suddenness, the disappearance being generally marked by the simultaneous vanishing of large sums of money. To-day the manufacture is entirely carried out in large works scientifically organized and supervised, and, both industrially and commercially, the speculative element has been eliminated.

Chemistry has so often been called on to play the part of the humble and unrecognized handmaiden to the industrial arts that we may perhaps be pardoned if in this case we direct public attention to our Cinderella as she shines in her rightful position as the genius of industrial initiation and direction.

To this essentially chemical development of metallurgy we owe it that in a community the age of which

can only be counted by decades we find ourselves surrounded by chemists of high scientific skill and attainments who have already organized for their mutual aid and scientific enlightenment "The Johannesburg Society of Chemistry, Metallurgy, and Mining," the published proceedings of which amply testify to the atmosphere of intellectual vigor in which the work of this great industry is carried on.

It appears, then, that while gold still maintains its position of influence in the affairs of men, the nature of that influence has undergone an important change. Not only has its widespread use as the chief medium of exchange exercised far-reaching effects on the commerce of the world, but the vastly increased demand for this purpose has in its turn altered the methods of production. These methods have become more highly organized and scientific, and gold production is now fairly established as a progressive industry in which scope is found for the best chemical and engineering skill and talent.

The experience of more highly evolved industries in the older countries has shown that the truly scientific organization of industry includes in its scope a full and just consideration for the social and intellectual needs of its workers from highest to lowest. It augurs well, therefore, for the future of the gold industry, from the humane and social points of view, that its control should be more and more under the influence of men of scientific spirit and intellectual culture who we may feel assured will not forget the best traditions of their class.

The application of science to industry requires on the part of the pioneers and organizers keen and persistent concentration on certain well-defined aims. Any wavering in these aims or any relaxation of this concentration may lead to failure or to only a qualified success. This necessary but narrow concentration may be a danger to the intellectual development of the worker, who may thereby readily fall into a groove and so may become even less efficient in his own particular work. It certainly requires some mental strength to hold fast to the well-defined practical aim while allowing to the attention occasional intervals of liberty to browse over the wide and pleasant fields of science. But I am certain that the acquirement of this double power is well worth an effort. The mental stimulus, as well as the new experiences garnered during the excursion, will sooner or later react favorably on the practical problems, while the earnest wrestling with these problems may develop powers and intuitions which will lend their own charm to the wider problems of science.

MADAME CURIE'S RECENT INVESTIGATIONS OF POLONIUM.

MADAME CURIE has been making a series of researches upon polonium which present a great interest. For some ten months past she carried out a series of measurements in order to find the law of the diminution of activity with time. The polonium which was used in these researches was prepared according to the method which the author employed previously. We extract first the salt of bismuth which the ore contains. To do this we precipitate the hydrochloric acid solution of the ore by hydrogen sulphide, separate the sulphides, dissolve them in dilute nitric acid and precipitate the solution by water. The mixture of subnitrates and oxides thus obtained is treated with a boiling soda solution which removes the lead, arsenic, and antimony. By repeating these treatments we obtain an oxide of bismuth containing polonium which is quite pure. To concentrate the polonium we dissolve this oxide in nitric acid and carry on a series of fractional precipitations by water, the most easily precipitated portions being the most active. To carry out the present researches on the loss of activity with time, we place a certain quantity of poloniferous oxide of bismuth of average activity (some 250 times that of uranium) in a shallow circular cavity in a metal dish. The oxide powder thus has a well-determined surface. The active plate thus formed is carefully kept and its radio-activity is measured at the proper intervals of time. The intensity of the rays is estimated by the saturation current produced in a two-plate condenser and the current is measured by M. Curie's electrometer method.

The first results of the measurements are as follows: It is found that the strength of the radiation lessens in function of the time by a simple exponential law. Letting I_0 represent the initial strength, I the strength after a time t , a being a constant, we find $I = I_0 e^{-at}$. If t is given in days, we have the constant $a = 0.00495$. According to this relation the strength of the radiation diminishes by half its value in a time equal to 140 days. The variation between the measured points and the theoretical formula is not more than 3 per cent. When plotted as a curve we find practically a straight line.

It is to be remarked that the constants which define the radio-active properties of bodies play a part which is quite comparable to that of the wave-lengths of the rays in the spectra of elements. When a radio-active matter is mixed in very small quantity with an inert matter, the constants which we deduce from the radiation may serve to detect and characterize it without any doubt. Thus the constant a of the above formula is quite characteristic of polonium. The time-constant which we have just found for polonium gives a very certain proof that the body observed by Marckwald under the name of "radio-tellurium" is identical with polonium. This identity already seemed evident after his account of the properties of this body. It is made certain by the fact that the constant we find for po-

lonium is the same as he already found for the former body, this having been $a = 0.00497$. Polonium and radio-tellurium are thus found to be one and the same substance, and it is evident that the name "polonium" should be employed, seeing that it is much anterior to the radio-tellurium. The author utilized the method of concentration employed by Marckwald, as it is a very convenient one. This consists in plunging a plate of bismuth in a hydrochloric acid solution of the radio-active bismuth salt. The polonium deposits upon this plate. We also used platinum plates covered with a thin layer of bismuth by electrolysis, and concentrated the polonium upon these plates. They are very convenient for observing the radio-activity, for they do not require the same precaution as the plates covered with oxide powder. We may remark that it is not to be supposed that polonium has the reactions of tellurium rather than those of bismuth. It is true that in a hydrochloric acid solution it is partly thrown down by proto-chloride of tin, but on the other hand in presence of bismuth its sulphide is insoluble in ammonium sulphide and the oxide is insoluble in a boiling soda solution. To observe the reactions of polonium, we must have it in the ponderable state. At present we can only see what are its reactions when it is contained in minute proportions in other bodies.

CONTEMPORARY ELECTRICAL SCIENCE.*

RADIO-ACTIVITY OF LAVA.—T. Tommasina has examined lava from last year's eruption of Vesuvius. The pieces examined included a piece taken warm from the summit of the crater and four pieces from the Valle d'Inferno, each containing a coin or medal. The lumps produced a dissipation of charge amounting to 42 volts per hour, whereas the apparatus when empty discharged 10 volts per hour. The author also powdered the specimens and distributed the powder over the inner surface of the apparatus. He then found a rate of dissipation as high as 84 volts per hour.—T. Tommasina, *Physikalische Zeitschrift*, October 26, 1905.

GLOW DISCHARGE IN HALOGENS.—W. Matthies has followed up his work on mercury haloids by studying the glow discharge in the halogens themselves. There is much similarity between the two classes of bodies. As in the case of the mercury haloids, the luminous phenomena are nearly the same as in pure nitrogen. But the potential gradient is very high in the halogens, and increases from the cathode toward the anode. Moreover, it is not a linear function of the pressure, but increases at first more rapidly than the pressure, and afterward more slowly. The normal cathode fall increases approximately as the molecular weight, and is independent of pressure and current strength.—W. Matthies, *Physikalische Zeitschrift*, November 1, 1905.

WORK OF WINDMILLS.—M. Ringelmann has made some determinations of the relation between velocity of wind and speed of revolution of windmills employed for raising water. The experiments extended over two years and were made with a pump having 72 vanes 1.3 meters long, with a total surface of 9.4 square meters. The pump was left to its own working all the time, being self-turning and self-regulating and going out of gear with a wind velocity exceeding 10 meters per second. The ratio between the velocity of the vane-rim and the wind varied from 0.82 at 4 meters per second to 0.75 at 10 meters. The volume of water raised 10 meters was 1,566 liters per hour at the former speed and 3,527 liters at the latter speed.—M. Ringelmann, *Comptes Rendus*, October 30, 1905.

IONIZATION AND ALTITUDE.—B. Brunhes and A. Baldit find that altitude above the earth's surface is not a very fundamental factor in ionization. In a plain at 330 millimeters the ionization may be the same as on a plateau at 1,200 millimeters, but a peak may show a very decided difference with the same difference of altitude. The increased electric field on the summit of mountains has little effect on the negative dissipation, but it considerably reduces the positive dissipation. Thus at the base of the Puy de Crouel, in the Puy de Dôme district, the negative and positive dissipation were 13 and 12 volts per minute respectively, while at the summit they were 12 and 6.—Brunhes and Baldit, *Comptes Rendus*, October 30, 1905.

BRAUN TUBE WITH SLOW CATHODE RAYS.—A. Wehnelt showed two years ago that comparatively slow cathode rays, generated with about 500 volts, are capable of producing very perceptible phosphorescence when their density, measured by coulombs per square centimeter per second, is considerable. Such slow rays may be obtained by coating the cathode with calcium, barium, or strontium oxides. A patch of a few square millimeters on a platinum cathode suffices. The latter is mounted facing the cathode, which has a small perforation, and the pencil thus picked out is conducted between two condenser plates to a fluorescent screen. A continuous current supply of 220 or 440 volts may be employed, or a few cells of a high-tension battery, since the current is only a few milliamperes. The tube must be highly exhausted, since the rays have great ionizing power, and ionization discharges the condenser. Since the cathode is only feebly red hot, the light from it does not interfere with observation of the phosphorescent spot. This form of Braun tube, besides being more sensitive to electric forces, is also useful in all cases where the high electrostatic forces of the ordinary Braun tube are undesirable. The cathode is used up very slowly, and the hardness of the rays may be varied within wide limits.—A. Wehnelt, *Physikalische Zeitschrift*, November 1, 1905.

* Compiled by E. E. Fournier d'Albe in the *Electrician*.

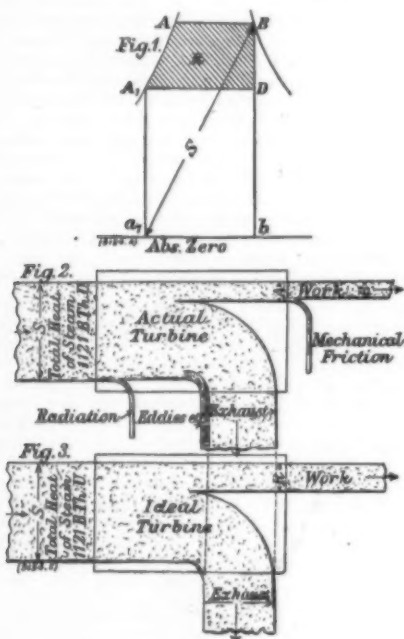
NOTE ON STEAM-TURBINES.

By CAPT. H. RIAL SANKEY, R.E. (ret.), M.Inst.C.E.,
M.I.Mech.E.

THE following diagrams illustrate the production of motion energy in steam-turbines of various types, and the conversion of this energy into mechanical work; and it is hoped that they may be of assistance to those who are beginning to study the steam-turbine.

The matter is regarded from the standpoint of a flow of energy into, through, and out of the turbine. A portion of the energy flow is converted into work, another portion leaks out during passage through the turbine in the form of radiation and conduction, but by far the greater amount flows away into the exhaust. Even if the turbine were ideally perfect—that is to say, if there were no radiation or conduction losses, and the conversion into work were the maximum theoretically possible—the portion flowing away in the exhaust would still be very considerable. As is well known, for saturated steam the maximum conversion is that of the Rankine cycle, and is exhibited on the energy chart in Fig. 1 by the shaded area marked R , and the area $a_1 A B b$ represents the total energy flow, or rather, it is the heat energy expended on each pound of steam to raise the pound of water from the exhaust temperature and convert it into steam at the admission temperature. If 100 deg. F. be chosen as the exhaust temperature corresponding to 28 inches of vacuum, or to approximately 1 pound absolute pressure; and if 366 deg. be taken for the admission temperature, corresponding to very nearly 165 pounds absolute pressure, it will be found that $R=317$ British thermal units, and the heat going away in the exhaust will be represented by the area $a_1 A D b=804$ British thermal units.

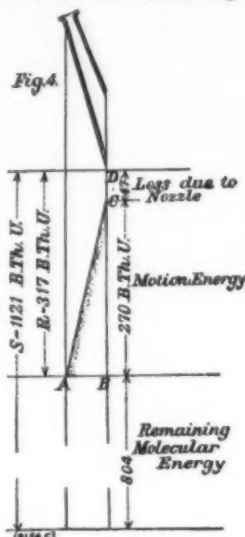
Adapting a diagram originally prepared by the writer for the introduction to the report of the Thermal Efficiency Committee of the Institution of Civil Engineers to the case in hand, Figs. 2 and 3 are ob-



tained for an actual and an ideally perfect turbine. The admission and exhaust pressures and temperatures are taken at the same values as in Fig. 1, and it will be supposed that 1 pound of steam per second is flowing through the turbine, corresponding to about 200 brake horse-power. This is, of course, a very small turbine; but the reasoning is not affected thereby. The width of the stream of energy is 8 British thermal units per second when reckoned equal to 1,121 British thermal units in the numerical example under consideration from 100 deg. F. The issuing stream, representing mechanical work, is of width R (317 British thermal units) for the ideal turbine, and of width A (220 British thermal units) for the actual turbine. A/R is the thermal efficiency of the actual turbine, and the ratio A/R is the "efficiency ratio" as defined by the Thermal Efficiency Committee. In the numerical example the thermal efficiency is 19.5 per cent, and the efficiency ratio equals 69 per cent. These figures have been reckoned on what corresponds to the indicated horse-power, so that actually A must be further reduced to the width B to allow for mechanical frictional resistances in the turbine, as shown in Fig. 2; the ratio B/R , equal in this case to 64 per cent, might be called the *brake efficiency ratio*, and in the case of a turbine seems to be the best ratio to take.

Directly the steam enters the turbine it is made to acquire a considerable velocity by being expanded through nozzles or blades of suitable shapes. The motion energy thus created is derived from the molecular energy of the steam, which is reduced by the exact amount thus created. Thus in Fig. 4, if A represents the entry to a nozzle, and R is plotted equal to the heat utilization of the Rankine cycle, at B , the exit from the nozzle, the height BC would represent the motion energy of the issuing jet, and the balance CD would be partly in the form of eddies, the remainder lost as radiation. If the nozzle were perfect, the point C would move to D , and the motion energy imparted to

the steam would be equal to R , and the ratio BC/BD is the efficiency of the jet. A line, AC , would represent the amount of motion energy at every section of the nozzle, and the shape of this line would depend on the shape of the nozzle. If the jet plays on suitably-shaped vanes, the motion energy will be converted into work; and if the steam came to rest on issuing from the mov-



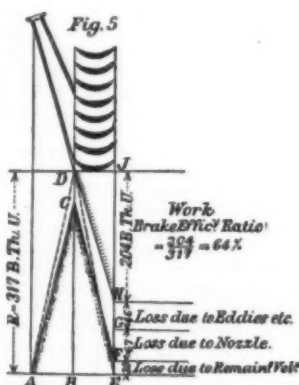
ing vanes, the whole of the motion energy would be converted into work. Actually, however, in the case of a single row of moving blades, this velocity of the steam would be about 1,000 feet per second, corresponding to 20 British thermal units per pound of steam; and this energy is represented in Fig. 5 by the height EF ; then FG is plotted equal to CD , and thus represents the loss due to the inefficiency of the nozzle; and the balance GH represents eddies, radiation, etc. The remainder, HJ , is converted into work, and clearly the

ratio $\frac{JH}{JE}$ is the brake efficiency ratio, equal in the

numerical example under consideration to 64 per cent. CF gives the reduction in motion energy as the steam passes through the openings between the moving blades, and the dotted lines, AD , DE , represent the conditions in the ideally perfect turbine.

In Fig. 6 the idea is extended to a turbine having an additional set of fixed and moving blades, as indicated diagrammatically. The issuing velocity from the first row of moving blades will be considerably greater than in the previous case; consequently, a smaller portion of the motion energy will be converted into work in the first row of moving blades. In passing through the fixed blades no work is done, as shown by the horizontal line, but the motion energy will be somewhat reduced, as shown by the sloping line; the motion energy thus lost will reappear as heat. The second row of moving blades converts a further portion of the motion energy into work; and finally, as before, $\frac{JH}{JE}$ is the brake efficiency ratio of the turbine.

Fig. 7 represents an element of the Parsons parallel-flow turbine, drawn to a much larger scale than the previous figures, and it will be noticed that in this case motion energy is produced both in the fixed and moving blades; it is, of course, only in the moving blades that mechanical work is done as indicated in Fig. 7. The curves shown, however, are only diagrammatical. The results obtained above have been applied to turbines of various types, following the classification pro-



posed by Mr. Neilson, in a paper he read before the Manchester Association of Engineers. His Classes I. and III. have already been dealt with in Figs. 5 and 6. The Laval and the single-disk Rateau turbine are practical examples of Class I. Class III. is represented by one type of the Riedler-Stumpf turbine. Figs. 8 to 10 deal with the remainder of Neilson's classification, and the names of some of the actual turbines at present being manufactured are noted against each figure.

In Figs. 8 and 9 the loss due to the nozzles is indicated by the vertical distance between the motion-energy line and the lower chain-dotted line, and the loss due to eddies, etc., is measured vertically from

	Neilson's Classification.	Names of Actual Turbines.
Fig. 8.....	Class II.	{ Rateau Multistage, Zoelly, Hamilton Holzwarth.
Fig. 9.....	Class IV.	{ Curtis, Riedler-Stumpf.
Fig. 10	Class V.	Parsons.

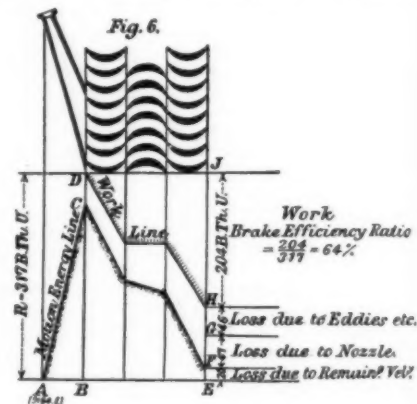
the "work" line to the upper chain-dotted line. The distance between the two chain-dotted lines gives that portion of the utilizable energy in the steam (317 British thermal units) still remaining as molecular energy in the steam at the various stages in the turbine. In Fig. 8 the temperature and pressure are also shown, on the supposition that one-third of the total utilizable energy is dealt with by each of the three sections of the turbine. The rapid drop of pressure in the first section is very noticeable.

In the case of the Parsons turbine (Fig. 10) the alternate rows of blades are so numerous (50 to 80) that they cannot be shown to so small a scale; therefore only three sets of fixed and moving blades have been drawn to a larger scale than the rest of the figure. Both the "work" line and the motion-energy line will therefore be in the shape of a saw, following DH and AF respectively. For the sake of comparison the brake-efficiency ratio has been taken as the same as in the case of the other turbines, although for so small a Parsons turbine as 200 brake horse-power this ratio would be less. Similar diagrams can obviously be drawn for any other form of turbine by combining, as may be necessary, the diagrams given in Figs. 5, 6, and 7.—Engineering.

MANUFACTURE OF HYDRAULIC CEMENTS.*

By L. L. STONE.

IN preparing a paper on the subject of cement it is fully recognized that many articles have already been prepared on this subject, and that various descriptions of it have repeatedly been written. Yet, the extensive developments in the cement industry, both from an engineering and financial standpoint, are commanding



such unusual attention that the manufacture of cement is very much discussed. It is then the purpose of this paper to give here as complete a description of the processes of manufacture as possible, free from the cumbersome figures which may be obtained at length from any factory report.

The term hydraulic cement is applied to any cement which possesses the property of hardening under water. Under these cements are included the three chief commercial cements of the present time, viz.: natural, slag and Portland cements. The general process of manufacturing and hardening is similar in the three classes. Each is a compound consisting chiefly of lime, silica, and alumina, calcined at a high temperature and the product reduced to a fine powder. The compounds of lime, silica, and alumina are produced by thoroughly mixing some form of carbonate of lime with the exact proportion of clay.

Natural cement was the first cement manufactured in this country, and was extensively used some years ago when nearly all Portland cement was imported from Europe. It is still used to a small extent but only for work of secondary importance. It is made in several places throughout the country from natural deposits of rock containing nearly the same proportions of lime rock and clay as are used to produce Portland cement. If a uniform deposit of rock containing exactly the correct proportions of rock and shale could be found, a natural cement, equal in grade to Portland cement, could be made of it, by simply burning and grinding; but since a variation of a very few per cent in composition is sufficient to destroy or greatly reduce the value of the resulting cement, there never has been found a natural rock deposit sufficiently uniform to produce a cement of this quality. In many cases it is only by the most careful sorting and mixing of certain portions of the raw material that cement can be made from it at all. The process of manufacture is very simple—the rock is quarried and burned at a comparatively low temperature and ground to a powder. It is slower in setting than Portland cement and does not develop as great strength.

Slag cement is made by mixing blast furnace slag with some form of lime, then burning and grinding.

* Read before the University of Michigan Engineering Society.

It can also be made from the forms of rock discharged from volcanoes, and it is thought that this is the source of the cement used by the Romans in their engineering work. Its manufacture was introduced into this country more to provide a way of disposing of the vast amount of slag accumulating at the larger blast furnaces than for its demand as a cement. The slag as it comes from the furnaces is generally granulated by contact with cold water. It is then mixed with slaked lime and heated and the resulting mass finely ground. A description of the machinery employed in these processes has not been given for it is similar to that used in the manufacture of Portland cement which will be described more in detail.

Portland cement was first made in England about the year 1825. It derives the name "Portland" from Portland Island rock, from which cement was first made. While the essential features of the process of manufacturing were there discovered, cement was not manufactured to any great extent until it was introduced into Germany and Belgium. It is still manufactured in those countries on a very extensive scale, but up to a few years ago little attention was given to improvements of the old system. Its manufacture was not begun in this country to any great extent until about fifteen years ago. Up to 1891 over 80 per cent of the cement used in this country was imported from Europe. It was about this time that engineers began to discover

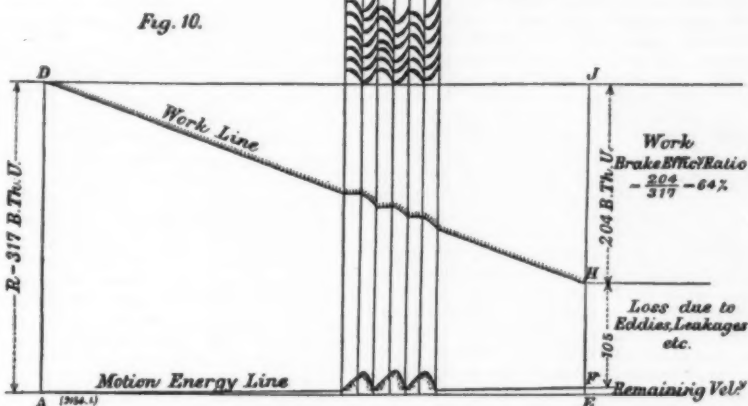
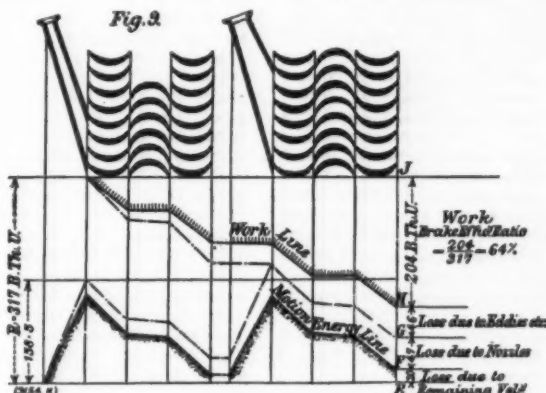
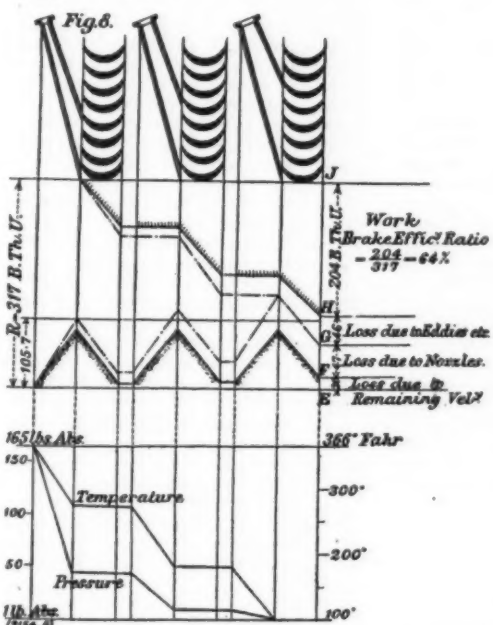
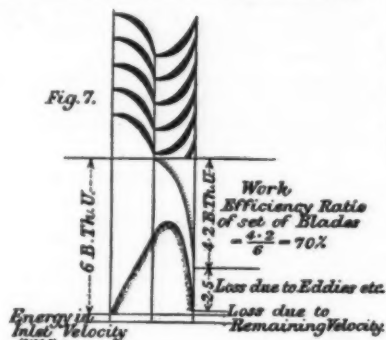
shale. It is in determining the proportion of this mixture that the first work of the operating chemist begins. Analyses of both materials are made and the variation in chemical composition is so corrected as to result in a mixture containing the proper elements to produce Portland cement. The materials are then ground to a fineness such that about ninety per cent will pass through a sieve of one hundred meshes per lineal inch. Burr stones were formerly used for this purpose, but they have been replaced by more economical grinding apparatus. A number of different types of mills have been devised for grinding rock, but either a Griffin mill or a combination of a ball and tube mill are generally used in this country.

The Griffin mill operates a revolving vertical shaft suspended from a central point, on one end of which is a fixed round head about eighteen inches in diameter with a six-inch face. This head rotates in a swinging motion inside of a thirty-inch tire, thus generating a centrifugal force which grinds the material between the surfaces of the head and tire. Above the tire is a circular screen through which the rock is thrown by an iron fan on the shaft as soon as it becomes sufficiently fine. It then drops through openings in the bottom of the mill where it is received by suitable screw conveyors.

The ball mill consists of a circular shell about eight feet in diameter by six feet in length lined with perforated steel plates. It contains a number of round steel balls from three to five inches in diameter, which, when the mill is revolved, fall on the pieces of rock and crush them till they pass through the perforated plates and leave the mill. This mill is not suitable for a finishing mill, but is very good to reduce the crushed rock sufficiently to allow about eighty per cent to pass through a twenty-mesh screen.

It is usually found in a swamp or lake and mined by the use of a dredge. It is removed to the plant by tram cars or is pumped by compressed air. The marl, as it is usually obtained, contains between sixty and eighty per cent of water. As four hundred and fifty pounds of carbonate of lime are required for one barrel of cement, this percentage shows that from fourteen hundred to eighteen hundred pounds of water must be evaporated from the marl for each barrel of cement. Due to the close union of the water and marl, no mechanical process has yet been discovered for separating them. The only possible way to remove the water without a prohibitive consumption of fuel is by means of evaporation. The latter process was formerly employed, always accompanied by a high cost of operation, but with the invention of kilns designed to receive the raw material in the form of slurry, the factories using marl are now operated under the wet process. In the marl process the grinding is comparatively simple. The marl is mixed by weight with the proper amount of clay and ground wet, making an exceedingly fine slurry.

Under the wet and semi-dry processes the slurry is carefully tested before being fed into the kilns. The test is an all-important one and determines almost entirely the quality of cement that will be produced by the mill. The only mix thus far in the operation is the rough or approximate one made when the two materials were first introduced to the mill. The final test is now made and the exact correction made. If the mix runs above the required percentage of rock, enough shale or clay is added to secure the proper composition. The same treatment is made if the mixture runs too high in shale, carbonate of lime being then added to secure the proper composition. These tests are made with the greatest precision on all materials before being



that cement could be produced here as well as in Germany. Improved machinery was devised to compete against the cheap hand labor of the European mills, and as a result cement is manufactured here of equal strength and at far less cost than that of foreign cements. At present practically all of the cement used in this country is American made, except the small percentage used in the few seaboard towns where a high freight makes importation profitable.

In the manufacture of this cement the factories are divided by the nature of the process used in three classes; the wet, semi-wet, and dry processes, all methods being extensively used.

In mills operating under the dry or semi-dry processes, the methods of handling the raw materials are the same. The carbonate of lime is generally obtained from dry lime stone or chalk rock and the silicates from clay and shale. The rock and shale are quarried by the use of air or steam drills and high explosives. Small surface cars are generally used to transfer the quarried rock to the mill where it is crushed in gyratory crushers of various sizes. In quarrying the shale, the fact that it is readily disintegrated by the action of the air is sometimes utilized; large masses of the shale being blasted loose to allow the free action of the air, thus permitting it to be more readily transported. It is then passed through a pulverizer and stored in large bins separately from the rock. The crushed rock has been reduced by this process to such a size that nearly all of it will pass through a one-inch screen and the shale is in the form of a coarse powder.

The materials are then passed separately through rotary dryers where a small percentage of the moisture is removed. A portion of the rock is then taken by weight and mixed with the correct amount of dried

The tube mill is a steel cylinder twenty-two feet long by five feet in diameter, revolving at about twenty-nine revolutions per minute. It is lined with an extremely hard quartz and loaded with flint pebbles about two inches in diameter. The material is reduced to the required fineness by the pounding and rubbing of these pebbles. It is at this point that the different methods are used which distinguish the mill as being of the dry or semi-dry process. Under the dry process the ground rock is conveyed from the mills and stored in suitable bins from which it is fed by feeding mechanisms into the kilns. If the semi-dry process is used, the powder is mixed with thirty per cent of water making a thin mud or slurry. This slurry is stored in steel tanks and is kept agitated by large revolving sweeps or by blasts of compressed air until it is fed by gravity or pump into the kilns.

In manufacturing cement under the dry or semi-dry process about six hundred pounds of raw material are required to produce one barrel of cement. It is thus seen that the water added under the semi-dry process must be removed by burning. There is much discussion among cement engineers as to the practical value of this system. While it requires an extra amount of fuel to evaporate the added water, it is claimed that the cost of this difference of fuel is compensated, especially in the natural gas fields, by the power saved in grinding, less wear in the kilns, due to lower temperatures, and greater assurances of uniform cement of the best quality. The raw material is used in the semi-dry process several per cent coarser than in the dry process, and it also allows a further correction after grinding, which cannot be made under the dry process.

When marl is used to supply the carbonate of lime

allowed to leave the tanks. Any number of corrections necessary are made to secure the correct composition for any particular materials. In the dry process this exact mix is made by weight before the materials are ground, which insures an intimate mix by grinding.

A great number of different kilns or furnaces have been devised for burning cement rock but only two have been extensively used. In the European mills a type of vertical kiln is used. These kilns have a vertical body similar to an inverted cone. The dried slurry is loaded into the kiln in alternate layers with the fuel and fire placed at the bottom. The heat and gases of the fire pass upward through the mass in irregular openings, consequently the resulting clinker is not of a uniform nature, part being overburdened, part being underburdened, and part in the proper condition, and all has to be sorted before being used. The waste gases from the kiln are conducted through long chambers so as to utilize the heat of the kiln during operation for evaporating the moisture from the slurry. When this type of kiln is properly built it is economical in fuel but requires a great deal of hand labor for operation, which is detrimental in this country. These kilns have been placed in but few of the American mills, those being among the first built.

The kilns in which practically all of the cement in this country is burned are known as rotary kilns. They consist of a steel cylinder six to seven feet in diameter by sixty to eighty feet in length, constructed of steel sheets one-half to nine-sixteenths inch in thickness. This shell revolves from one-fourth to one revolution per minute, and is carried by very true locomotive tire steel rings which ride on cast steel rollers. These rolls are so elevated that the kiln is deflected from the horizontal between one-half to three-quarters of an inch per

foot. The kiln is operated by a large girth gear into which meshes a train of gears that reduce the speed from two hundred to one so as to receive power from an electric motor or line shaft. When this type of fuel was first tried much difficulty was experienced in securing the proper combustion of fuel. Its successful operation was first secured by the use of crude oil, but owing to its cost, a substitute was necessary. Coal was then tried and is now almost exclusively used except where natural gas is found in large quantities. The coal is ground to a fineness of ninety per cent to pass through a hundred mesh screen and is shot into the kiln by a continuous blast of compressed air. The heat is regulated by varying the amount of coal. If gas is used for a fuel it is generally passed through a cast-iron burner which creates the proper mixing of gas and air for complete combustion. To burn or calcine the raw materials, a heat of from twenty-eight hundred to thirty-two hundred degrees Fahrenheit is required. For this reason the kiln is lined for nearly its entire length with from nine to twelve inches of extremely refractory brick. In the process of burning, the dry rock or slurry is fed into the upper end of the kiln and gradually moved toward the lower end by its inclination and revolution. The process is thus seen to be continuous and with the variations in speed of kiln, the amount of raw material fed into it, and the regulation of the amount of fuel, is entirely under the control of the operator. The product thus formed is of uniform grade and all burned to a proper degree of hardness.

The process of burning is a most important one in the manufacture of cement and open to great improvement, consequently this department receives probably more attention than any other of the operations involved. The first successful rotary kiln was five feet in diameter by thirty feet in length, but this size was gradually increased to six feet in diameter and sixty feet in length which was regarded as standard until four of five years ago. While this kiln has a greater capacity and gives more uniform results than the old type of vertical kiln, the amount of fuel required for its operation is much greater than that required by the old system of burning.

The vertical kiln requires about forty pounds of coal to burn one barrel of cement, while it requires from a hundred to a hundred and fifty pounds of coal to burn one barrel of cement in the rotary kiln. But when the vertical kiln is used the raw material must be made up in the form of briquettes and placed in the kiln and after being burned a certain time, taken out. This is all accomplished by hand labor, which prevents the successful use of this kiln in this country.

After the practical success of the rotary kiln was established manufacturers began to modify the kiln in the hope of securing greater economy.

When this kiln is in operation it creates a stack temperature of from seven to twelve hundred degrees F., and the line of improvement has been to endeavor to utilize this waste heat. A number of different methods have been devised, but only two have been developed to a working basis. By one method the waste gases are passed through steam boilers supplemented by direct furnace fire, thus utilizing the waste heat for the generation of power. The chief objections to this system are the excessive cost of the complicated machinery, the difficulty of suitably placing the boilers and furnaces and the presence of more or less dust in the gases which behaves very unfavorably in the furnaces.

The other method is to utilize the hot gases to heat the raw material which is done by increasing the length of the kilns. This idea is the more practicable of the two and kilns were previously developed up to a length of eighty feet beyond which, due to mechanical reasons, it was not considered practical to continue. But this idea was most strikingly developed in a factory designed by Thomas A. Edison where two kilns were built nine feet in diameter by one hundred and fifty feet in length. These kilns produced the most economical results of any rotary kilns yet made and burned cement with from twenty-five to thirty-five pounds less coal per barrel than any kiln of this type up to this time has done. However, a number of mechanical difficulties arose which interfered with the continual operation of the kilns and for these reasons it was not considered by many engineers a complete success. Several modifications of this type of kiln have since been made in the hope of securing an ideal size. In the year of 1902 four kilns seven feet in diameter by one hundred feet in length were designed by the Hunt Engineering Company and installed in the works of the Western Portland Cement Company two years later. These kilns reduced the stack temperature to slightly over four hundred degrees F., and gave such satisfactory results that the same company is now equipping a plant in southern Kansas with ten kilns eight feet in diameter by one hundred and ten feet in length, so installed as to operate under either the dry or semi-dry process.

The product as it is discharged from the rotary kiln is in the shape of small, black, and very hard pellets. It is very hot and must be cooled before grinding. This is usually accomplished by some artificial means. One method is to pass the clinker through a rotary cooler, similar in construction to a rotary kiln with the exception of the lining, from three to five feet in diameter and from thirty to fifty feet in length, through which passes a forced blast of cold air. Another method is by the use of large steel tanks in the body of which are placed perforated cast-iron ducts which divert currents of cold air through the heated mass. In some mills it is cooled by slightly sprinkling with water and in others by letting it lie in large heaps to cool by radiation. About four per cent of gypsum is

then mixed with the clinker and it is ground into cement by the same style of mill as is used to reduce the rock.

The cement materials are subjected to chemical and physical tests in all departments. These tests are conducted in laboratories which are found at all plants. In the chemical department all chemical analyses are made and the proportions of rock and shale are here determined. The samples of slurry are here analyzed and the proper amount of correction computed. The clinker is also analyzed to determine its soundness and composition and the quality of burning. Also, a final test is made of all finished cement before shipment. A sample is also kept from each shipment for future reference should any complaint be registered against any shipment of cement.

In the physical laboratory tests of strength, time of setting, and results under accelerated conditions are determined. The cement is molded into small briquettes about four inches long which are of one square inch sectional area in the center and somewhat larger at each end. The briquettes are pulled in two by a testing apparatus and tensile strength per square inch thus registered. Small cubes are also made one inch on edge and the load required to crush them noted. Briquettes made of cement and twenty per cent of water seven days old must test about four hundred and fifty pounds tensile strength. The compressive strength is generally from twenty to twenty-five times the tensile strength.

The setting of cement is in two periods, designated as the initial and final set. The initial set must take place in from twenty-five to forty minutes and this is considered to be acquired when a sample of cement will bear without indentation a wire one-twelfth inch in diameter and loaded to weigh one-fourth of a pound. The final set is considered to have been acquired when the mixture will bear a wire one-twenty-fourth of an inch in diameter, loaded to weigh one pound. The time of setting is regulated by the amount of gypsum ground into the cement. When the clinker and gypsum are ground together every particle of cement is covered with a coating of gypsum which requires a certain length of time for the water to penetrate. It is this required time which delays the action of the cement and water that determines the time of setting and is regulated by the proper amount of gypsum. The accelerated tests are intended to produce in a short time the same effect as that of longer periods under a normal climatic condition. They consist chiefly in placing the hardened cement in cold water, in boiling water and under steam pressure for several hours. The samples must in all cases remain perfectly sound and show no checks or abrasions in the surfaces. These systems of testing serve as a check on the various processes of manufacture, and guarantee to the consumer a product of the best quality.

CEMENT MORTAR AND CONCRETE: THEIR PREPARATION AND USE FOR FARM PURPOSES.*

By PHILIP L. WORMLEY, JR.

INTRODUCTION.

THE many letters received and referred to the Office of Public Roads with reference to the use of cement and the adaptability of concrete for various farm purposes have made it seem advisable to issue a short bulletin on the subject, in which a proper method of mixing concrete is described, together with a few of the many uses for which concrete is well adapted. No attempt has been made to give a technical discussion of the subject, the sole object being to treat in an elementary way those points in concrete construction which are of particular interest to the farmer.

In the appendix will be found the results of tests made to determine the strength of reinforced concrete fence posts, together with tests showing the effect of retempering Portland cement mortar.

CEMENT.

The term "hydraulic cement" is applied to one of the most useful materials of engineering construction and one which in recent years has become widely extended in its field of application. Hydraulic cement possesses the property of hardening, or setting, under water, in which respect it differs from lime, which does not harden except in the presence of air. Thus it is evident that in all places where air is excluded, such as foundations, thick walls, etc., cement mortar should be used instead of lime.

Only two classes of cement will be discussed here—Portland and natural. The difference between these is due partly to the method of manufacture and partly to the condition and relative proportions of the materials employed, which are, generally speaking, limestone and clay. In the manufacture of Portland cement the separate materials are mixed in such proportions as have been found by experience to give the best results. The mixing is done by grinding the materials together in mills, after which the mixture is burned at a very high temperature in kilns, and the resulting clinker ground to an impalpable powder is known as Portland cement. In the case of natural cement the materials used have been already mixed by nature in approximately the correct proportions, being found in the form of a rock which is generally classed as a clay limestone, or a limy deposit technically called calcareous clay. This material is burned at a much lower temperature than Portland cement.

When the manufacturer has each ingredient absolutely under control and can adjust the proportions to suit all conditions, it is reasonable to expect that a better and more uniform product will result than when the materials are found already mixed. Portland cement is far more extensively employed than natural cement on account of its superior strength, although the latter is frequently used in cases where great strength is of little importance. The superior strength and durability of cement as compared with lime, together with the low price at which it may now be procured, have caused the former to replace the latter in engineering construction to a great extent.

Storing Cement.

In storing cement care must be exercised to insure its being kept dry. When no house or shed is available for the purpose, a rough platform may be erected clear of the ground, on which the cement may be placed and so covered as to exclude water. When properly protected, it often improves with age. Cement is shipped in barrels or bags, the size and weight of which usually are as follows:

Bulk and Weight of Cement in Ordinary Barrels and Bags.

Kind of Cement.	Per Barrel.		Per Bag.	
	Quantity, Cu. Ft.	Weight (Net), Pounds.	Quantity, Cu. Ft.	Weight (Net), Pounds.
Portland.....	3 1/4	380	7 1/2	95
Natural*.....	3 1/2	300	7 5/8	75

* Western natural cement usually weighs about 285 pounds per barrel net.

Cement Mortar.

Cement mortar is an intimate mixture of cement and sand mixed with sufficient water to produce a plastic mass. The amount of water will vary according to the proportion and condition of the sand, and had best be determined independently in each case. Sand is used both for the sake of economy and to avoid cracks due to shrinkage of cement in setting. Where great strength is required, there should be at least sufficient cement to fill the voids or air spaces in the sand, and a slight excess is preferable in order to compensate for any uneven distribution in the mixing. Common proportions for Portland cement mortar are 3 parts sand to 1 of cement, and for natural cement mortar, 2 parts sand to 1 of cement. Unless otherwise stated, materials for mortar or concrete are considered to be proportioned by volume, the cement being lightly shaken in the measure used.

A "lean" mortar is one having only a small proportion of cement, while a "rich" mixture is one with a large proportion of cement. "Neat" cement is pure cement, or that with no admixture of sand. The term "aggregate" is used to designate the coarse materials entering into concrete—usually gravel or crushed rock. The proportion in which the three elements enter into the mixture is usually expressed by three figures separated by dashes—as, for instance, 1-3-5—meaning 1 part cement, 3 parts sand, and 5 parts aggregate.

In the great majority of cases cement mortar is subjected only to compression, and for this reason it would seem natural, in testing it, to determine its compressive strength. The tensile strength of cement mortar, however, is usually determined, and from this its resistance to compression may be assumed to be from eight to twelve times greater. A direct determination of the compressive strength is a less simple operation, for which reason the tensile test is in most cases accepted as indicating the strength of the cement.

Mixing.

In mixing cement mortar it is best to use a platform of convenient size or a shallow box. First, deposit the requisite amount of sand in a uniform layer, and on top of this spread the cement. These should be mixed dry with shovels or hoes, until the whole mass exhibits a uniform color. Next, form a crater of the dry mixture, and into this pour nearly the entire quantity of water required for the batch. Work the dry material from the outside toward the center, until all the water is taken up, then turn rapidly with shovels, adding water at the same time by sprinkling until the desired consistency is attained. It is frequently specified that the mortar shall be turned a certain number of times, but a better practice for securing a uniform mixture is to watch the operation and judge by the eye when the mixing has been carried far enough. In brick masonry the mistake is frequently made of mixing the mortar very wet and relying upon the bricks to absorb the excess of water. It is better, however, to wet the bricks thoroughly and use a stiff mortar.

Grout.

The term "grout" is applied to mortar mixed with an excess of water, which gives it about the consistency of cream. This material is often used to fill the voids in stone masonry, and in brick work the inner portions of walls are frequently laid dry and grouted. The practice in either case is to be condemned, except where the conditions are unusual, as cement used in this way will never develop its full strength.

Lime and Cement Mortar.

L. C. Sabin* finds that in a Portland cement mortar containing three parts sand to one of cement, 10 per cent of the cement may be replaced by lime in the

* Reprint from Farmers' Bulletin, No. 235, issued by the Department of Agriculture.

* Sabin, L. C., Cement and Concrete, 1906.

form of paste without diminishing the strength of the mortar, and at the same time rendering it more plastic. In the case of natural cement mortar, lime may be added to the extent of 20 to 25 per cent of the cement with good results. The increased plasticity due to the addition of lime much facilitates the operation of laying bricks, and has caused lime and cement mortar to become largely used.

Cement Mortar for Plastering.

In plastering with cement, a few precautions must be observed to insure good and permanent results. The surface to receive the plaster should be rough, perfectly clean, and well saturated with water. A mortar very rich in cement is rather a drawback than otherwise on account of shrinkage cracks, which frequently appear. The mortar, consisting of two or three parts sand to one of cement, should be mixed with as little water as possible and well worked to produce plasticity. It is essential that the plaster be kept moist until it has thoroughly hardened.

MATERIALS FOR MAKING CONCRETE.

Sand.

In securing sand for mixing mortar or concrete, if it is possible to select from several varieties, that sand should be chosen which is composed of sharp, angular grains, varying in size from coarse to fine. Such sand is, however, not always obtainable, nor is it essential for good work. Any coarse-grained sand which is fairly clean will answer the purpose. If gravel, sticks, or leaves be present they should be removed by screening. The voids in sand vary from 30 to 40 per cent, according to the variation in size of grains. A sand with different-sized grains is to be preferred, because less cement is required to fill the voids. By mixing coarse and fine sand it is possible to reduce the voids considerably.

It is customary to use the terms "river sand," "sea sand," or "pit sand," according to the source of supply. River sand as a rule has rounded grains, but unless it contains an excess of clay or other impurities, it is suitable for general purposes. When river sand is of a light color and fine-grained it answers well for plastering.

Sea sand may contain the salts found in the ocean. The tendency of these salts to attract moisture makes it advisable to wash sea sand before using it for plastering or other work which is to be kept perfectly dry.

Pit sand for the most part will be found to have sharp, angular grains, which make it excellent for mortar or concrete work. Where clay occurs in pockets it is necessary either to remove it, or else see that it is thoroughly mixed with the sand. The presence of clay in excess frequently makes it necessary to wash pit sand before it is suitable for use.

The results of tests made in this laboratory would indicate that the presence of clay, even in considerable amounts, is a decided benefit to "lean" mortars, whereas it does not appreciably affect the strength of a rich mixture.

Gravel.

It is important that gravel for use in concrete should be clean, in order that the cement may properly adhere to it, and form a strong and compact mass. As with sand, it is well to have the pieces vary in size, thereby reducing the voids to be filled with mortar. The voids in general range from 35 to 40 per cent.

Crushed Stone.

The best stone for concrete work consists of angular pieces, varying in size and having a clean, rough surface. Some form of strong and durable rock is to be preferred, such as limestone, trap, or granite. The total output of the crusher should be used below a maximum size, depending upon the nature of the work in hand. All material under one-eighth inch will act as so much sand and should be considered as such in proportioning the mixture. Precautions must be taken to insure a uniform distribution of the smaller pieces of stone, otherwise the concrete will have an excess of fine material in some parts and a deficiency in others.

Less than 8 per cent of clay will probably not seriously impair the strength of the concrete, provided the stones are not coated with it, and may even prove a benefit in the case of lean mixtures. The voids in crushed stone depend upon the shape and variation in size of pieces, rarely falling below 40 per cent, unless much fine material is present, and in some cases reaching 50 per cent. A mixture of stone and gravel in equal parts makes an excellent aggregate for concrete.

Stone Versus Gravel.

It would appear from tests that crushed stone makes a somewhat stronger concrete than gravel, but the latter is very extensively used with uniformly good results. This superiority of stone over gravel for concrete work is attributed to the fact that the angular pieces of stone interlock more thoroughly than do the rounded pebbles, and offer a rougher surface to the cement. A point in favor of gravel concrete is that it requires less tamping to produce a compact mass than in the case of crushed stone. Then, too, the proportion of voids in stone being usually greater than in gravel, a proportionately greater amount of mortar is required to fill the voids, which means a slight increase in the cost of concrete.

Cinders.

Cinder concrete is frequently used in connection with expanded metal and other forms of reinforcement for floor construction, and for this purpose it is well adapted on account of its light weight. Its porosity makes it a poor conductor of heat and permits the driving of nails. Only hard and thoroughly burned

cinders should be used, and the concrete must be mixed quite soft so as to require but little tamping and to avoid crushing the cinders. Cinder concrete is much weaker, both in tension and compression, than stone or gravel concrete, and for this reason admits only of light reinforcement.

CONCRETE.

General Discussion.

Cement concrete is the product resulting from an intimate mixture of cement mortar with an aggregate of crushed stone, gravel, or similar material. The aggregate is crushed or screened to the proper size as determined from the character of the work. In foundation work, stone or gravel 3 inches in size may be used to advantage, whereas in the case of molded articles of small sectional area, such as fence posts, hollow building blocks, etc., it is best to use only such material as will pass a one-half inch screen. An ideal concrete, from the standpoint of strength and economy, would be that in which all voids in the aggregate were completely filled with sand, and all voids in the sand completely filled with cement, without any excess. Under these conditions there would be a thoroughly compact mass and no waste of materials.

It is a simple matter to determine the voids in sand and also in the aggregate, but in mixing concrete the proportions vary a great deal, depending in each case upon the nature of the work and the strength desired. For example, in the construction of beams and floor panels, where maximum strength with minimum weight is desired, a rich concrete is used, whereas in massive foundation work, in which bulk or weight is the controlling factor, economy would point to a lean mixture. When good stone or gravel is used, the strength of the concrete depends upon the strength of the mortar employed in the mixing, and the proportion of mortar to aggregate. For a given mortar the concrete will be strongest when only enough mortar is used to fill the voids in the aggregate, less strength being obtained by using either a greater or less proportion. In practice it is usual to add a slight excess of mortar over that required to fill the voids in the aggregate.

It is more accurate to measure cement by weight, unless the unit employed be the barrel or sack, because when taken from the original package and measured in bulk there is a chance of error due to the amount of shaking the cement receives. As it is less convenient, however, to weigh the cement it is more common to measure it by volume, but for the reason stated this should be done with care.

Proportioning Materials.

For an accurate determination of the best and most economical proportions where maximum strength is required, it is well to proceed in the following way: First, proportion the cement and sand so that the cement paste will be 10 per cent in excess of the voids in sand; next, determine the voids in the aggregate and allow sufficient mortar to fill all voids, with an excess of 10 per cent.

To determine roughly the voids in gravel or crushed stone, prepare a water-tight box of convenient size and fill with the material to be tested; shake well and smooth off even with the top. Into this pour water until it rises flush with the surface. The volume of water added, divided by the volume of the box, measured in the same units, represents the proportion of voids. The proportion of voids in sand may be more accurately determined by subtracting the weight of a cubic foot of packed sand from 165, the weight of a cubic foot of quartz, and dividing the difference by 165.*

For general use the following mixtures are recommended:

1 cement, 2 sand, 4 aggregate, for very strong and impervious work.

1 cement, 2½ sand, 5 aggregate, for ordinary work requiring moderate strength.

1 cement, 3 sand, 6 aggregate, for work where strength is of minor importance.

Aggregate Containing Fine Material.

In the case of gravel containing sand, or crushed stone from which the small particles have not been removed by screening, the amount of such sand or fine stone should be determined and due allowance made for it in proportioning the mortar.

When mixing an aggregate containing small particles with mortar, the same conditions obtain as if these particles had been screened from the aggregate and added to the sand used in making the mortar, and in reality we have a mortar containing a larger proportion of sand than was present before the aggregate was incorporated. It is evident, then, that in such cases the quality or richness of the mortar should depend upon the proportion of fine material in the aggregate.

For example, suppose that 1 cubic foot of gravel contains 0.1 cubic foot of sand, and that the voids in gravel with sand screened out measure 40 per cent. For general purposes this would suggest a 1-2-5 mixture, but since each cubic foot contains 0.1 cubic foot sand, 5 cubic feet of gravel will contain 0.5 cubic foot

*The following will serve as an example of proportioning materials: Assume voids in packed sand to measure 38 per cent and voids in packed stone to measure 48 per cent. Cement paste required per cubic foot of sand = $0.38 \div 0.38 = 0.43$ cubic foot, approximately. By trial 1 cubic foot of loose cement, lightly shaken, makes 0.85 cubic foot of cement paste, and requires —, or 2 cubic feet of sand, producing

an amount of mortar equal to $0.85 + 2(1 - 0.38) = 2.09$ cubic feet. Mortar required per cubic foot of stone = $0.48 \div 0.48 = 0.528$ cubic foot.

Therefore 2.09 cubic feet mortar will require — = 4 cubic feet of stone, approximately. The proportions are, therefore, 1 part cement, 2 parts sand, 4 parts stone. Although such a determination is usually considered unnecessary in practical work, it may be of sufficient interest to justify giving it.

sand, and the proportions should be changed to 1 part cement, 1½ parts sand, 5 parts gravel.

Mechanical Mixers.

It has been demonstrated that concrete can be mixed by machinery as well, if not better, than by hand. Moreover, if large quantities of concrete are required, a mechanical mixer introduces marked economy in the cost of construction. None of the various forms of mechanical mixers will be described here, since concrete in small quantities, as would be used on the farm, is more economically mixed by hand.

Mixing by Hand.

In mixing concrete by hand a platform is constructed as near the work as is practicable, the sand and aggregate being dumped in piles at the side. If the work is to be continuous, this platform should be of sufficient size to accommodate two batches, so that one batch can be mixed as the other is being deposited. The cement must be kept under cover and well protected from moisture. A convenient way of measuring the materials is by means of bottomless boxes or frames made to hold the exact quantities needed for a batch.

A very common and satisfactory method of mixing concrete is as follows: First measure the sand and cement required for a batch and mix these into mortar as already described. Spread out this mortar in a thin layer and on top of it spread the aggregate, which has been previously measured and well wetted. The mixing is done by turning with shovels three or more times, as may be found necessary to produce a thoroughly uniform mixture, water being added if necessary to give the proper consistency. The mixers, two or four in number, according to the size of the batch, face each other, and shovel to right and left, forming two piles, after which the material is turned back into a pile at the center. By giving the shovel a slight twist, the material is scattered in leaving it and the efficiency of the mixing is much increased.

Consistency of Concrete.

A dry mixture, from which water can be brought to the surface only by vigorous tamping, is probably the strongest, but for the sake of economy, and to insure a dense concrete well filling the molds, a moderately soft mixture is recommended for ordinary purposes. Where the pieces to be molded are thin, and where small reinforcing metal rods are placed close together or near the surface, a rather wet mixture may be necessary to insure the molds being well filled.

Use of Quick-Setting Cement.

In the manufacture of such articles as pipe, fence posts, and hollow blocks, a rather large proportion of quick-setting cement is sometimes used, the object being to reduce the weight and consequent freight charges by means of a strong mixture, as well as to make the concrete impervious to water. The use of a quick-setting cement permits the molds to be removed sooner than would be possible with a slow-setting cement, thus reducing the number of molds necessary for a given output. Quick-setting cements are not recommended for such purposes, however, as they are usually inferior to those which set slowly.

Coloring Cement Work.

In coloring cement work the best results are obtained by the use of mineral pigments. The coloring matter, in proportions depending upon the desired shade, should be thoroughly mixed with the dry cement before making the mortar. By preparing small specimens of the mortar and noting the color after drying, the proper proportions may be determined.

For gray or black, use lampblack.

For yellow or buff, use yellow ochre.

For brown, use umber.

For red, use Venetian red.

For blue, use ultramarine.

Depositing Concrete.

Concrete should be deposited in layers of from 4 to 8 inches and thoroughly tamped before it begins to harden. The tamping required will depend upon the consistency of the mixture. If mixed very dry it must be vigorously rammed to produce a dense mass, but as the proportion of water increases less tamping will be found necessary. Concrete should not be dumped in place from a height of more than 4 feet, unless it is again mixed at the bottom. A wooden incline may be used for greater heights. Rammers for ordinary concrete work should weigh from 20 to 30 pounds and have a face not exceeding 6 inches square. A smaller face than this is often desirable, but a larger one will be less effective in consolidating the mass. In cramped situations special forms must be employed to suit the particular conditions. When a thickness of more than one layer is required, as in foundation work, two or more layers may be worked at the same time, each layer slightly in advance of the one next above it and all being allowed to set together. At the end of a day there is usually left a layer partially completed which must be finished the next day. This layer should not be beveled off, but the last batch of concrete should be tamped behind a vertical board forming a step.

To avoid introducing a plane of weakness where fresh concrete is deposited upon that which has already set, certain precautions have to be observed. The surface of the old work should be clean and wet before fresh material is put on, a thin coating of neat cement grout being sometimes employed to insure a good bond. The surface of concrete to receive an additional layer must not be finished off smoothly, but should offer a rough surface to bond with the next layer. This may be done by roughing the surface while soft with pick or shovel, or the concrete may be so rammed as to present a rough and uneven surface.

Wooden blocks or scantling are sometimes imbedded several inches in the work and removed before the concrete hardens, thus forming holes or grooves to be filled by the next layer.

Retempering.

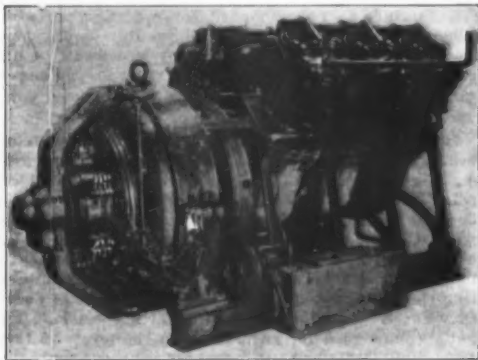
As stated before, it is important that concrete be tamped in place before it begins to harden, and for this reason it is proper to mix only so much at a time as is required for immediate use. The retémpering of concrete which has begun to set is a point over which there is much controversy. From tests made in this laboratory it would appear that such concrete suffers but little loss of strength if thoroughly mixed with sufficient water to restore normal consistency.

The time required for concrete to set depends upon the character of the cement, upon the amount and temperature of the water used in mixing, and upon the temperature of the air. Concrete mixed dry sets more quickly than if mixed wet, and the time required for setting decreases as the temperature of the water rises. Warm air also hastens the setting.

(To be continued.)

A NEW GASOLINE ELECTRIC RAILWAY CAR.

Progress in long-distance electric transmission has made it possible to operate extensive interurban railways which are gradually encroaching upon what has always been considered as the exclusive business of steam railroads; but electric traction of the present type has its limitations, for the reason that, in addition to the ordinary construction of track and roadbed, electric railroads must also have power houses and sub-stations, with expensive machinery, pole lines for heavy copper feeders, overhead systems, rail bonds, and innumerable other details, most of which are short-lived and require a large corps of attendants for their maintenance. The need of a successful means for meeting and preventing the competition of electric lines is being felt by many of the main trunk lines, but few of them have installed a third rail or trolley system for this purpose, because of the heavy initial expense and the likelihood of the early introduction of re-



80-HORSE-POWER, 6-CYLINDER, 4-CYCLE GASOLINE ENGINE DIRECT-CONNECTED TO 250-VOLT, 50-KILOWATT DYNAMO.

liable independent motor cars. Having nothing definite under consideration, railway companies are allowing franchises for parallel lines to be secured by competitors, thereby shutting them out of valuable fields of operation.

Mr. William B. Strang has perfected a system that perhaps meets all the requirements of an independent electric car. Briefly, this system is a combination of a gasoline engine, a dynamo, and storage battery. The engine furnishes the power to run the dynamo and generate electricity for the motors that operate the car, and the storage battery, on the one hand, receives the surplus power from the generator when the load is light, and on the other hand, furnishes the excess power required during acceleration and on steep grades.

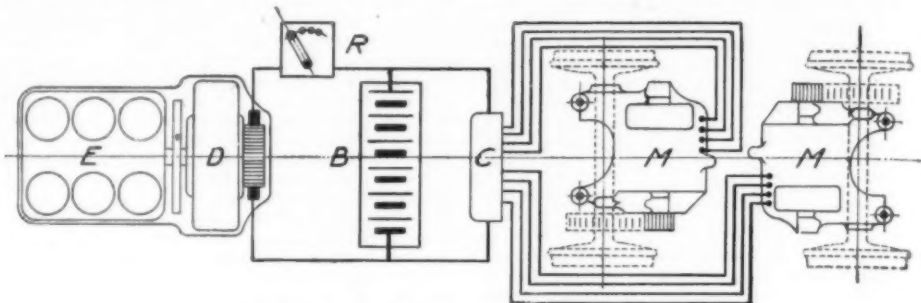
The use of a generator and motors to transmit power between the engine and the wheels of a motor car may, at first sight, seem unnecessary. This combination, however, has proven highly satisfactory. Considered merely as a clutch and change gear it is superior in simplicity and economy to any mechanical appliance for a similar purpose.

The special car which is herewith illustrated was built by the J. G. Brill Company from plans and specifications furnished by the Strang Electric Railway Car Company, and is mounted on high-speed trucks of the Brill No. 27-E type having rolled steel wheels. The trial trips have been made on the main line of the Baltimore & Ohio Railroad between Philadelphia and Wilmington, and officials of that railroad, of the Pennsylvania Railroad Company, of the American Locomotive Company, and prominent railway men from New York and elsewhere have made up the parties and have watched the operation of the car with intense interest. The new car left last week for the West. The Brill Company is building several more cars of the same type, which will measure 52 feet 9 inches over the vestibules. These cars will have smoking and passenger compartments and are to be mounted on high-speed trucks of the Brill No. 27-E type. They will be used by the Missouri & Kansas Interurban Railway Company in the operation of its line running over the Santa Fé trail from Kansas City, Mo., to Olathe and southwestern Kansas.

The great advantage of the Strang system is that

it requires an engine only large enough to develop the average power used. The engine is of special construction, and includes a number of governing devices which are unique in design and operation. The general plan of the system is shown in the accompanying diagram and consists of a gas engine with a direct-connected generator, electric transmission and control, direct connection between the generator and the truck motors, and a storage battery.

The engine is of the four-cycle type and has six



GENERAL PLAN OF THE STRANG SYSTEM.

E. Engine. D. Dynamo. B. Battery. C. Controller. M. M. Motors. R. Starting rheostat.

8 x 10 cylinders. To secure a short crank shaft and reduce vibration to the minimum, the cylinders are partially opposed, three on each side, and are set at an angle of ninety degrees to each other. An advantage of this construction is in the accessibility of the parts. The bearings and wearing surfaces in general are much larger than customary, but the weight of the entire engine is reduced by using aluminum for covering parts where there is no strain. The engine frame is a substantial cast-steel structure, securely bolted to a rectangular base of the same material. The vaporizer is arranged to work with the utmost economy with all



THE ENGINE ROOM OF THE GASOLINE-ELECTRIC RAILWAY CAR AS SEEN THROUGH THE FRONT WINDOW.

kinds of loads. Kerosene, alcohol, or crude oil may be used instead of gasoline with a slight change of adjustment of the vaporizer. The ignition is of high-tension, or "jump spark" type, with coils of a special design, one coil for each cylinder, and all operating from one interrupter. The commutator is driven from the end of the cam shaft and is outside the casing at the rear of the engine. The oil is contained in a reservoir placed beside the base of the engine. It is pumped to the different bearings, and is returned to a filter located over the reservoir. A centrifugal pump belted

to the flywheel draws water from a tank in the vestibule at the center of the car and forces it through the cylinder jackets and to radiating pipes upon the roof. In cold weather the passenger compartment is heated by the water from the cylinder jackets. The gasoline is stored in absolute safety in a tank underneath the car floor, and is pumped to an overflow cup at the side of the vaporizer and the excess returned by another pipe, to the tank. The coils of the storage battery are placed on a cradle underneath the center of

the car. By the use of 250 voltage instead of the usual 500 the number of cells is reduced and a more reliable insulation is secured.

The electrical equipment consists of a 50-kilowatt 250-volt direct-current generator direct-connected to the gasoline engine, which makes 400 R. P. M.; two 50-horse-power series-wound motors of regular street-railway type; two K-13 controllers; and a storage battery of 112 cells having 200 ampere hours capacity.

The transmission of power from the engine to the

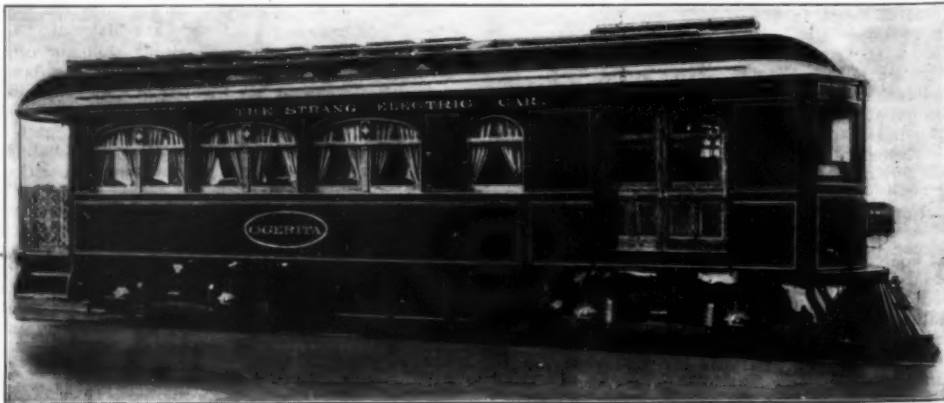
driving wheels by means of direct electric connection between the dynamo and controller and motors obtains a transmission which is the most efficient under all conditions of any in practical use at present, and by means of the series-parallel controller, an effective speed-changing and reversing apparatus is secured without additional gears, clutches or other mechanical appliances. By the addition of the battery the full benefit of the flexibility, reliability, and economy is gained in this combination.

For running on a level track under ordinary conditions, the current goes directly from the generator to the motors, but when coasting down grade, slowing up, or standing still, the surplus of current is taken up by the batteries and furnishes the extra power necessary for acceleration, and for ascending steep grades. This arrangement is entirely automatic and does not require to be watched by the operator.

The use of a direct-connected gasoline engine requires one which is large enough for the maximum load. Therefore it runs most of the time at one-third its normal power, is disconnected when the car is standing still or coasting, and only uses its full power for very short periods, making regulation difficult and wasting fuel, while in the Strang system the inclusion of the storage battery enables the engine to run practically at the same speed at all times, with the air and fuel adjusted once and for all for the best possible combustion. The battery acts as a balance or equalizer and the engine takes care of the normal load.

The system is in line with first-class power houses where the peak of the load is carried in the same manner. The battery is of comparatively small size, as it is rarely called upon to furnish current for more than a few minutes at a time. Ordinary use improves and is necessary to keep a battery in good condition, and it is entirely practical to build a battery of small capacity with long life.

As to preventing the battery from being overcharged while running with a light load, it will be remembered that it requires a pressure of two and one-half volts to charge a storage battery, while during discharge the pressure falls to about two volts. The average voltage supplied to the motors practically corresponds to their rating, and therefore, with a light load, they will run faster in the endeavor to use it up, while with a heavy load the voltage will fall sufficiently to allow the batteries to assist the engine in furnishing



A NEW GASOLINE-ELECTRIC CAR FOR USE ON SHORT RAILWAY LINES.

the necessary current. In other words, the electric transmission being elastic, there is always a tendency to adjust the speed of the car to that which is most suitable and economical for the primary power equipment. Moreover, the engine is provided with automatic governing devices dependent entirely upon the condition of the batteries and the consumption of current. This arrangement has nothing to do with the speed of the engine or the motors, but is simply an additional safeguard against overcharging the battery.

ies, and is entirely automatic and solely for the purpose of economizing fuel and saving the battery when the engine is running light or standing still.

The switchboard is placed against the left side of the engine compartment within easy reach of the operator. It includes voltmeter, ammeter, starting rheostat, and spark control. The platform at the rear of the car is equipped with a controller and a combination volt and ammeter.

The maximum speed of the car which can be maintained is 50 miles per hour.

The average gasoline consumption is 45-100 gallon per car mile. One hundred gallons of gasoline are carried, which gives a mileage radius of 225 miles.

THE DAVY 336,000-POUND RAPID-ACTION FORGING PRESS.

By the English Correspondent of SCIENTIFIC AMERICAN.

A new type of rapid-action forging press has been devised by the well-known Sheffield engineers, Messrs. Davy Brothers, Ltd., which possesses many interesting and novel features, by means of which the efficiency and the rapidity of the action is materially increased. With this press, the power of which is 336,000 pounds, working at full power a speed of 80 strokes per minute can be easily maintained. Hitherto the prevailing practice has been to utilize presses for only heavier forgings, but this particular appliance, owing to its speed, enables the same class of work to be carried out

efficiency is well demonstrated by the operation of the press with the tup in mid-air. Under these conditions, with a complete absence of all resistance in the hydraulic intensifier, the steam intensifier takes a full stroke upon the complete motion of the handling lever, the intensifier starting rapidly but gradually decreasing the velocity and coming quietly to rest at the end of its stroke, so that the assistance of any cushioning is dispensed with. In the absence of any resistance the steam is automatically cut off, and the quantity admitted to the cylinder is proportional to the resistance offered. By this means not only is any excess of speed and violent action avoided entirely, but waste of steam is also obviated. The operator can also drop the press-head on to the forging in hand before admitting any steam to the intensifier, owing to the arrangement of the valve gear, and simultaneously the pressing stroke commences without any pause whatever, directly the tool comes into contact with the work.

The patent stuffing box devised by Messrs. Holmes and Davy is fitted to the hydraulic intensifier cylinder. This is an ingenious and efficient arrangement, since it enables the packing leather to be replaced without disturbing either the hydraulic cylinder or any of the working parts. Consequently there is no loss of time or labor involved in changing the leather, which can be accomplished in a few minutes.

The utmost rapidity of action is assured by the arrangement of the valves and gear, to which special attention has been devoted. The descent of the press

with their resinous components on extraction with ether or petroleum ether. The proportion of hydrocarbon to resin varied in the gutta percha from 61.4 : 38.6 to 39.6 : 60.4, while in the balata it was 46.5 : 53.5. The India rubber employed in comparative experiments was a specimen of Island Pará, which was quite free from dirt and yielded 2 per cent of empyreumatic and resinous matter to acetone.

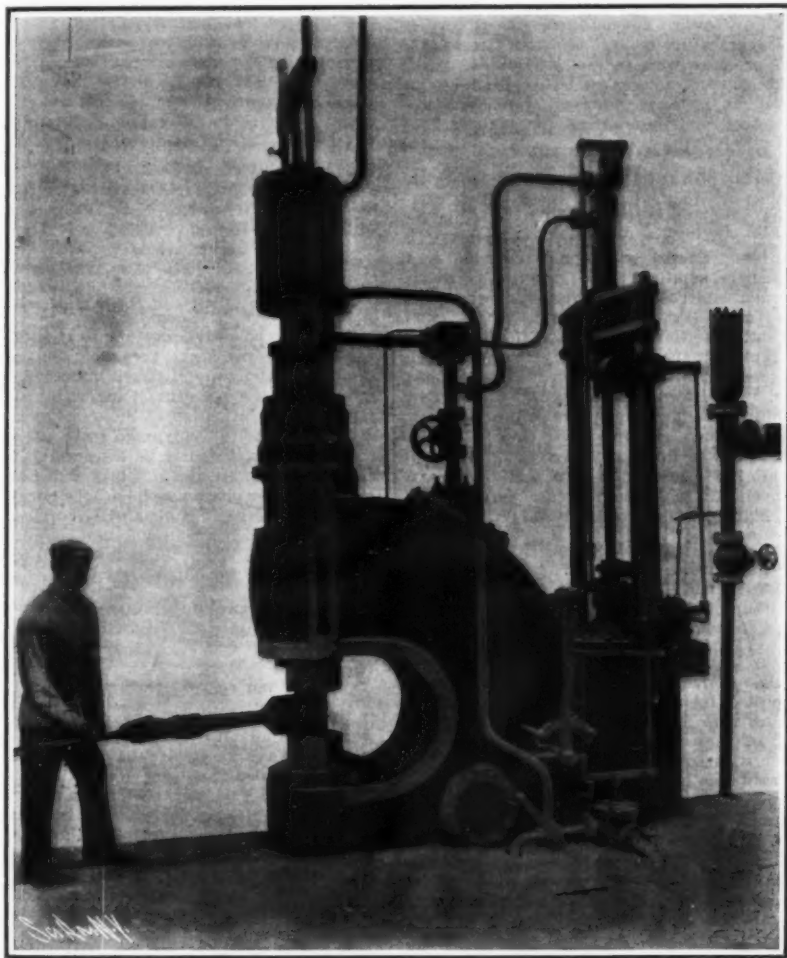
THE HYDROCARBONS.

These will be referred to later as gutta, balata, and caoutchouc respectively, under the generic term of polyene. The first step toward preparing gutta and balata in the pure state was to eliminate the small amount of dirt still present. The extracted materials were dissolved in benzene and the insoluble matter allowed to settle. The solutions are too viscous to be easily filtered, but they become perfectly clear on standing for 24 hours, especially after being shaken up with a few drops of water. The hydrocarbon may then be precipitated by alcohol or acetone. The color of the clear solutions varied from sherry-brown to pale yellow; it appears to increase with the small amount of ash (0.3—0.6 per cent) present, and is not removed by numerous re-solutions and reprecipitations; in quite dilute solution (1:100), however, the coloring matter is deposited as a fine powder on standing for some months. Balata was almost water-white in solution. On precipitation by alcohol, the bulk of the hydrocarbon comes down as a stringy mass of the texture of loofah, while the mother-liquor is milky and deposits the remainder in a finely-divided state on standing. The essential difference between these two forms claimed by Oesterle (this J., 1893, 609 and 848) was not confirmed. It appears to be merely a question of dilution whether stringy or fine gutta will be precipitated, and by starting with sufficiently dilute solutions a yield of the latter, without any clot, can always be obtained. The limit was found to be about 0.9 gr. in 100 c. c., and from solutions stronger than this the formation of a clot is inevitable. Caoutchouc, as is well known, contains a skeleton of matter which swells up, but remains insoluble in benzene and other solvents; from the clear solution an elastic coagulum is precipitated, which runs together to a comparatively dense mass.

Precipitated gutta readily absorbs oxygen, and is best dried and preserved in hydrogen. This precaution being taken, analysis by combustion showed that precipitated guttas were never free from oxygen; a specimen which was five times reprecipitated and then dried in hydrogen still contained 1 per cent. The oxidized constituent is not removed by extraction with petroleum ether and is not, therefore, a resin. It seems probable that the first oxidation products of gutta are colloids not far removed in their general properties from the parent hydrocarbon.

The final purification is effected by a process resembling recrystallization, for which ether, benzene, or ligroin may be employed. The pure hydrocarbon is thus obtained in white flakes or granules. Analyses of various guttas and balata, thrice deposited from benzene, confirmed the formula $(C_5H_8)_n$. The hydrocarbons derived from the ten gutta perchas and from balata were identical in general properties. The only difference observed was that solutions of equal strength showed slight differences in viscosity, that of balata having about twice the viscosity of average gutta solution; they are vastly more mobile, however, than corresponding caoutchouc solutions. Gutta is of leathery consistency and almost destitute of elasticity; in this respect it differs sharply from caoutchouc, which is highly elastic. At temperatures well below 100 deg. it becomes soft, and can be kneaded into any desired form, while caoutchouc becomes sticky and moderately plastic, but still retains some resiliency. At higher temperatures the two hydrocarbons tend to approximate in behavior. Gutta is soluble in ether, chloroform, carbon tetrachloride, carbon bisulphide, and hydrocarbons. Boiling sodium-proof ether takes up a small percentage of gutta and deposits the bulk in small flakes on cooling. The presence of water or alcohol in small amounts renders ether almost a non-solvent. In $CHCl_3$, CCl_4 , and CS_2 , gutta swells somewhat to a transparent mass and then yields, on shaking, a homogeneous solution in the cold. In benzene and its homologues gutta behaves differently; a quantity of solvent is taken up with swelling, but the resulting mass is not dispersed throughout the liquid on shaking unless the temperature be raised to 40 deg. or higher. Benzene solutions of gutta are supersaturated below 20 deg.; on local freezing, and often spontaneously, most of the gutta separates out in hyaline, gelatinous flakes which, when pressed dry, still contain half their weight of solvent. Apparently there is a temperature limit below which an insoluble gutta-benzene complex is favored and above which clear homogeneous solutions are stable. The solubility of gutta in paraffins increases with their molecular weight; cold petroleum ether of 30 deg. to 40 deg. B. P. is a non-solvent and is useful for the assay of resin by extraction. In the higher fractions gutta dissolves easily on boiling, but it does not absorb them in the cold. Ligroin of B. P. 60 deg.—80 deg., especially, is a very suitable "recrystallizing" medium, from which the gutta deposits in opaque granules on cooling. The above are also solvents for caoutchouc; this hydrocarbon swells up to an enormous volume, and the resulting jelly-fish-like mass goes into solution on shaking, at any temperature. There is hardly a liquid, solvent or non-solvent, which caoutchouc does not absorb with swelling. It does not grain out of solutions.

The specific gravity of the several guttas and balata was determined by precipitating in the finely divided



A 150-TON QUICK-ACTING FORGING PRESS

as with the ordinary hammer in point of rapidity, with which it competes very favorably.

This press is of the steam intensifier type, and is controlled by a single lever of short stroke, so that it can be operated easily and rapidly. There is a controlling gear in connection with the handling lever which operates upon the valve gear throughout the entire stroke by means of a hunting gear. Two prominent advantages accrue from this arrangement. In the first place the length of stroke of the intensifier is controlled to exactly the length of stroke given to the handling lever, rendering it much easier to adjust the stroke of the press to suit the work being carried out. In the second place the controlling-gear acts on the steam valve throughout the entire length of the stroke of the intensifier, gradually closing it and thereby preventing any excessive speed or violent action in the steam cylinder. This constitutes a valuable feature of the machine, since should the whole resistance in the press disappear suddenly through the forging slipping off the bed, the failure of a joint or pipe, or from any other misadventure, the steam intensifier is liable to become so violent and sudden as to impart a considerable shock on the handling lever, and cause damage to or breakage of parts, the usual provision for closing the steam valve in such emergencies coming into operation only when the steam piston has attained a dangerously high velocity and struck the reversing gear.

The controlling gear employed in this machine is the invention of Messrs. Holmes and Davy, and its

head is almost as rapid as that of a hammer, while at the same time the pressure of the intensifier continues the stroke of the press without any pause. The press is made, as will be seen from the accompanying illustration, with overhung steel frame with the intensifier fitted thereto, so that the plant is self-contained. The main advantage of such a press is that the forgings produced thereby are much sounder and more accurate than those obtained with a hammer, accompanied by a complete absence of noise and vibration, while the cost of operation, both from the points of tools and maintenance, is much lower, and accompanied by a smaller consumption of steam.

NOTES ON GUTTA PERCHA AND BALATA.*

By DR. W. A. CASPARI.

The following observations were made with the object, first, of extending the knowledge of the hydrocarbons of gutta percha and balata, generally, and, secondly, of bringing the chemistry of them into line, in certain respects, with that of India rubber.

Ten marketable varieties of raw gutta percha, outwardly different, were available. Of balata, which is less adulterated and is understood to vary little in quality for a given year, a specimen imported in 1902 was taken. These were mechanically freed from adventitious mineral and vegetable matter and rolled into porous sheets containing several per cent of water, in which condition they very readily parted

* Read before the Society of Chemical Industry.

state and floating in a suitably adjusted mixture of alcohol and water; it ranged between 0.9604 and 0.9619. Caoutchouc, which cannot be precipitated in fine flakes, does not lend itself to this procedure.

Action of Heat.—Gutta never attains a truly fluid condition. It becomes dough-like on warming, but the mass does not melt to a continuous bubble-free mass before decomposition sets in. When finely divided gutta is heated in ordinary melting-point tubes, the softening-point at 59 deg. to 60 deg. is marked by the hitherto opaque particles becoming translucent. At 185 deg. to 190 deg. vapor is evolved, and the decomposing substance runs together to a fused mass.

ADDITION PRODUCTS.

Chlorine.—Solutions of polyprene absorb chlorine with avidity. The nature of the solvent is not a matter of indifference, since, if it forms hydrochloric acid in reaction with chlorine, partial addition of HCl to the polyprene may take place. Thus, in benzine, products were obtained which contained fluctuating, and usually comparatively low, percentages of Cl. On passing pure dry chlorine into solutions of gutta, balata, and caoutchouc in dried carbon tetrachloride to saturation, most of the product separated out as a gummy mass, being easily soluble in hot carbon tetrachloride, but only sparingly in cold. There was a marked disengagement of hydrochloric acid. The liquids were poured into alcohol and the resulting clot redissolved and reprecipitated. By dropping dilute benzine or chloroform solutions into alcohol, the chlorinated bodies were obtained in small white flakes, which were dried *in vacuo*. They are toughish and of the consistency of bread crumbs. Below 100 deg. they become plastic, and at 150 deg. they darken with evolution of hydrochloric acid. They dissolve easily in the ordinary polyprene solvents.

Gutta: 0.1939 gr. gave 0.2801 CO₂ and 0.698 H₂O.
0.1788 gr. gave 0.4116 AgCl.
C = 39.46; H = 4.00; Cl = 56.98 per cent.
Balata: 0.1865 gr. gave 0.2466 CO₂ and 0.0624 H₂O.
0.1815 gr. gave 0.4418 AgCl.
C = 36.08; H = 3.72; Cl = 60.17 per cent.
Caoutchouc: 0.1767 gr. gave 0.2580 CO₂ and 0.0645 H₂O.
0.1276 gr. gave 0.2876 AgCl.
C = 39.84; H = 4.06; Cl = 55.79 per cent.
Required for C₁₀H₈Cl₂: C = 40.38; H = 4.03; Cl = 55.58 per cent.

From these figures, it is evident that more substitution than addition has taken place; the formula C₁₀H₈Cl₂ would indicate that 12 atoms of chlorine have been substituted, and two added, in the molecule C₁₀H₈.

Bromine.—Here again, the use of benzine as solvent leads to low bromine-contents (60–62 per cent). On conducting the reaction in dried chloroform, white amorphous bodies, very much resembling the above chlorination-products, were obtained, not without a slight disengagement of HBr. They darken with evolution of hydrobromic acid at 130 deg.

Gutta: 0.1988 gr. gave 0.2102 CO₂ and 0.0658 H₂O.
0.2044 gr. gave 0.3242 AgBr.
C = 28.68; H = 3.68; Br = 67.50 per cent.
Balata: 0.1412 gr. gave 0.1558 CO₂ and 0.0493 H₂O.
0.1773 gr. gave 0.2719 AgCl.
C = 30.08; H = 3.88; Br = 65.27 per cent.
Caoutchouc: 0.1688 gr. gave 0.1824 CO₂ and 0.0598 H₂O.
0.2114 gr. gave 0.3270 AgBr.
C = 29.48; H = 3.94; Br = 65.82 per cent.
Required for C₁₀H₈Br₂: C = 29.83; H = 3.82; Br = 66.34 per cent.

Bromine, then, has not nearly the same tendency to substitute in the polyprene molecule as chlorine. From the above approximate formula, an unsaturation corresponding to eight atoms of bromine per C₁₀H₈ molecule is indicated.

Iodine.—When the hydrocarbons are subjected to the action of excess of iodine in dry chloroform solution, a jelly separates beneath a clean dark brown solution, and after a day or two, the jelly shrinks to a leathery mass. Slight fumes of hydriodic acid are observed. By working with known weights of iodine, shaking up after three days with potassium iodide solution, and titrating, the iodine absorption values of 104, 105, and 92 for gutta, balata, and caoutchouc respectively were determined. But whereas compounds containing about 50 per cent of iodine might be expected from these data, it was found that on shaking up and precipitating with alcohol, a great part of the iodine was liberated again. The bodies thus obtained are grayish-brown flakes, capable of being finely powdered.

Gutta: 0.2012 gr. gave 0.0450 AgI.
I = 12.11 per cent.
Balata: 0.2584 gr. gave 0.0618 AgI.
I = 12.92 per cent.
Caoutchouc: 0.1315 gr. gave 0.0304 AgI.
I = 12.49 per cent.

By precipitating only the clear liquid resulting from the reaction in chloroform, very similar bodies of a rather lighter color were obtained.

Gutta: 0.1578 gr. gave 0.0364 AgI.
I = 12.49 per cent.
Balata: 0.1528 gr. gave 0.0380 AgI.
I = 13.47 per cent.
Caoutchouc: 0.1625 gr. gave 0.0382 AgI.
I = 12.72 per cent.

These substances are tolerably stable, and it thus appears that the bulk of the iodine absorbed in solution is held much more loosely than the residual 12–13 per cent. They shrink and darken at 180 deg., but do not give off notable quantities of iodine below 200 deg.

Once isolated, they are insoluble in chloroform and all other solvents, though they swell up more or less.

Hydrochloric Acid.—Benzene solutions of gutta and of balata were saturated with gaseous hydrochloric acid and precipitated with alcohol. The resulting clots were redissolved and reprecipitated, yielding white leathery flakes easily soluble in benzine, chloroform, etc. They begin to decompose at 185 deg.

Gutta: 0.1893 gr. gave 0.4255 CO₂ and 0.1614 H₂O.
0.2303 gr. gave 0.2788 AgCl.
C = 61.26; H = 9.48; Cl = 28.92 per cent.
Balata: 0.1348 gr. gave 0.3014 CO₂ and 0.1118 H₂O.
0.2223 gr. gave 0.2628 gr. AgCl.
C = 61.00; H = 9.22; Cl = 29.20 per cent.

The behavior of caoutchouc was found to be somewhat different. From benzene solutions hydrochloric acid gas brought down insoluble gelatinous flakes, which, after "drowning" in alcohol, yielded a friable substance capable of being finely powdered. It is easily soluble in chloroform and carbon bisulphide, but in benzine only swells without dissolving.

0.1026 gr. gave 0.2209 CO₂ and 0.0931 H₂O.
0.1690 gr. gave 0.2164 AgCl.
C = 58.72; H = 10.08; Cl = 31.72 per cent.

The difference in composition between gutta and caoutchouc hydrochlorides is not so great as might be expected from the difference in properties. The former correspond approximately to C₁₀H₈(HCl)₂, which requires C = 61.00; H = 8.98; and Cl = 30.01 per cent.

All these halogenized derivatives are exceedingly inert chemically. Toward aqueous reagents especially their state of aggregation renders them very resistant. Heated under pressure with sodium ethylate, they all pass into coffee-colored oxygenated bodies insoluble in all solvents; in no instance, however, were these obtained halogen-free, and therefore fit for analysis.

VULCANIZATION.

Sulphur chloride is absorbed by gutta and balata in the same way as by caoutchouc, and the resulting compounds closely resemble Weber's C₁₀H₈S₂Cl₂ (this J., 1894, 13, 14), but they only remotely approximate to this composition. Excess of sulphur chloride was mixed with benzine solution (2:100) of the hydrocarbons; the former had been thrice refractionated from the purchased article, and sodium-proof benzine was used throughout. The liquids set to stiff jellies, balata rather more rapidly than gutta. The jellies were comminuted by squeezing through calico, repeatedly washed with benzine, and drowned in acetone. Hard light yellow granules, yielding impalpable white powders, free from uncombined sulphur were thus obtained. Hydrochloric acid was invariably given off. The sulphur- and chlorine-contents of two sets of preparations are appended; in I. the reagents were allowed to stand for half an hour, in II. over-night.

		I.	II.
Gutta	Sulphur	20.6	23.4
	Chlorine	15.9	21.0
Balata	Sulphur	20.5	24.9
	Chlorine	15.5	20.2

Sulphur was found to vulcanize gutta and balata very effectively. In default of machinery, the materials were incorporated by softening the hydrocarbons in benzine, mixing with 5–10 per cent of powdered sulphur, driving off the solvent, and heating the mass in the steam-oven with frequent kneadings until tolerably uniform. It was then bound with canvas and subjected for three hours to 130 deg. in an autoclave. The resulting substances were of firm, springy consistency; they were cut into strips and deprived of free sulphur by extraction with carbon bisulphide and acetone. Preparations containing 1.72–2.33 per cent of sulphur became somewhat sticky on heating to 100 deg., and were therefore under-vulcanized. With 2.78 (gutta) and 2.69 (balata) per cent, however, they no longer resembled the parent hydrocarbons in any way. They were decidedly elastic, though less so than vulcanized caoutchouc; they swelled in solvents without dissolving; heated to 100 deg. they showed no trace of plasticity or stickiness, but rather gained in elasticity. Traces of H₂S were evolved in vulcanization. No vulcanizing effect was observed when the hydrocarbons were boiled with sulphur in xylene or heated with sulphur in toluene to 150 deg.

To determine the maximum absorption of sulphur, vulcanizations were carried out as above with equal weights of hydrocarbon and sulphur for five hours at 130 deg. (I.), and for ten hours at 160 deg. (II.). The resulting ebonites were rasped to powder and extracted for 24 hours with acetone:

I. Gutta:	0.1800 gr. gave 0.4084 BaSO ₄ . S = 31.18 per cent.
Balata:	0.1292 gr. gave 0.3100 BaSO ₄ . S = 32.90 per cent.
II. Gutta:	0.1023 gr. gave 0.2698 BaSO ₄ . S = 36.21 per cent.
Balata:	0.1756 gr. gave 0.4526 BaSO ₄ . S = 36.38 per cent.

These sulphur contents are of the order of those found by Weber (Gummi-Ztg., 1902, 16, 563) for the upper limit of caoutchouc vulcanization, with respect to which the formula C₁₀H₈S₂ (S = 32.00 per cent) is claimed. The higher figures of I., which are paralleled in Weber's experiments, point to substitutive action.

ACTION OF NITROGEN OXIDES.

The action of nitrogen oxides upon caoutchouc and gutta percha has been studied by Weber (Ber., 35,

1947) and by Harries (Ber., 35, 3256; see this J., 1902, 1404). In dealing with gutta and balata, nitrogen peroxide, prepared by acting on arsenic with nitric acid and mixing the gases with oxygen, was passed into benzene and the solution added to benzene solutions of the hydrocarbons. The first products of reaction were greenish gelatinous precipitates which dried to horny masses; they were not directly soluble in acetone, but passed into solution on standing; they were of variable composition, the nitrogen-contents fluctuating between 9 and 11 per cent. On adding more nitrogen peroxide, yellow clots separated, which soon became granular; they were filtered off and purified by dissolving in acetone and precipitating with ether. These substances are buff-colored impalpable powders, soluble in acetone and ethyl acetate with tawny color, also in caustic alkalis, but not in ammonia. They shrink about 90 deg., darken, and become pasty at 120 deg., and finally gases are slowly given off with charring. Concentrated H₂SO₄ dissolves them quietly.

Gutta: 0.1815 gr. gave 0.3488 CO₂ and 0.1133 H₂O.
0.3218 gr. gave 33.5 c.c. N at 15 deg. and 762 mm.
C = 52.44; H = 6.94; N = 12.42 per cent.
Balata: 0.1120 gr. gave 0.2144 CO₂ and 0.0706 H₂O.
0.3258 gr. gave 32.9 c.c. N at 15 deg. and 768 mm.
C = 52.31; H = 7.00; N = 11.20 per cent.
required for C₁₀H₈N₂O₂: C = 52.62, H = 7.02, N = 12.28 per cent.

On subjecting these bodies to the further protracted action of nitrogen peroxide, heat was evolved and bubbles of gas given off. The products, after reprecipitation by ether from acetone solution, were saffron-yellow powders soluble in acetone, ethyl acetate, alkalis, and ammonia with a deep orange color. The yield upon gutta and balata was 218 and 216 per cent respectively. These bodies intumesce at 160 deg. and deflagrate, yielding a puffy residue of carbon. They are decomposed violently by concentrated H₂SO₄.

Gutta: 0.1491 gr. gave 0.2169 CO₂ and 0.0675 H₂O.
0.2447 gr. gave 29.0 c.c. N at 9 deg. and 770 mm.
C = 41.50; H = 5.03; N = 14.63 per cent.
Balata: 0.1452 gr. gave 0.2231 CO₂ and 0.0680 H₂O.
0.2988 gr. gave 36.8 c.c. N at 15 deg. and 766 mm.
C = 41.89; H = 5.20; N = 14.76 per cent.
required for C₁₀H₈N₂O₂: C = 41.52, H = 5.19, N = 14.53 per cent.

Thus they are evidently identical with Harries' "nitrosite c" of the above formula. The gas evolved in their formation was analyzed and found to consist of nitrogen with 4 per cent of carbon dioxide. It is certain that the formation of these bodies is a step in the degradation of the polyprene molecule, and their further decomposition may be expected to throw light in this direction. By the action of reducing agents more or less nitrogenous, amorphous substances are produced, and in many cases ammonia is formed. Nitric acid eventually yields oxalic acid, but an intermediate yellow amorphous body soluble in alcohol was isolated for which Harries' formula C₁₀H₈N₂O₂ was confirmed:

0.2448 gr. gave 0.3518 CO₂ and 0.0993 H₂O.
0.2668 gr. gave 28.0 c.c. N at 19 deg. and 758 mm.
C = 42.65; H = 4.90; N = 12.31 per cent.
required for C₁₀H₈N₂O₂: C = 41.55, H = 4.85, N = 12.94 per cent.

The "nitrosite c" does not dissolve without decomposition in alkalis. The precipitated product, which, in other ways, resembled the original, contained only 12.42 per cent of nitrogen. On boiling the alkaline solution, a brown powder insoluble in aqueous liquids separates out, which contains alkali; in the mother liquors formic acid, nitric acid, and a yellow nitrogenous body soluble in ether and striking deep yellow with alkalis, were found.

Unexpected results were obtained by acting on benzene solutions of polyrenes with pure, dry nitric oxide. Alcohol precipitated yellow elastic gums soluble in acetone and chloroform. They go into solution on boiling with caustic and are reprecipitated in sticky clots.

Caoutchouc: 0.1140 gr. gave 0.2750 CO₂ and 0.0844 H₂O.
0.2714 gr. gave 16.6 c.c. N at 21 deg. and 761 mm.
C = 65.80; H = 8.23; N = 7.13 per cent.
Gutta: 0.1578 gr. gave 0.3736 CO₂ and 0.1174 H₂O.
0.3015 gr. gave 16.4 c.c. N at 22 deg. and 761 mm.
C = 70.31; H = 8.74; N = 6.32 per cent.
required for C₁₀H₈N₂O₂: C = 65.92, H = 8.79, N = 7.69 per cent.

Thus nitrogen and oxygen are not in the proportion in which they were supplied; probably the substances underwent oxidation in the course of purification.

It is noteworthy that all the nitrogenous derivatives here mentioned reduce Fehling's solution.

In conclusion, it is evident that the hydrocarbons of gutta percha and of balata are identical. As regards the comparison between gutta and caoutchouc, it has long been known that they behave similarly on destructive distillation and on nitration, and the above experiments indicate that there is no essential difference in the chemistry of these two forms of polyprene. It seems as if there were a common molecule, differences in the, perhaps polymeric, aggregation of which caused differences in mechanical structure. Any degradation of the molecule would lead to identical products, but in addition-products the differentia of the parent hydrocarbons might be transferred. Thus vulcanized gutta is far from identical with vulcanized rubber mechanically, and even the marked divergence in the solubilities of the hydrochlorides might be due to this.

RECENT PROCESSES INTRODUCED IN FRANCE FOR THE PRODUCTION OF STARCH.

Soluble Starch by the Bredt Process.—This process is said to furnish with water limpid solutions, which can be preserved for a long time. It may not only replace dextrine, but gelatine size and gum.

In principle, the process consists in submitting any amylaceous matter, as, for example, the fecula of potatoes or wheat or corn starch, or other similar matter, to the action of a permanganate in excess; that is, in sufficient quantity for the oxidation of the impurities accompanying the starch. The permanganate may be employed in the form of a neutral solution, alkaline or sulphatic.

If the starch is diluted in an aqueous or alkaline solution of a permanganate in excess, it will be converted after a time into soluble starch. The temperature for the operation may be between the ordinary temperature and one near that in which starch is converted into paste, or on the average, 50 deg. C. In the course of the process peroxide of manganese is formed and precipitated, and at the end of the reaction dissolved in the usual manner, by means of acids added to a reducer; as, for example, bisulphite, oxalic acid, or formaldehyde. The process may be modified by adding sulphuric acid to the washed starch at the commencement of the reaction. In this way the precipitate of manganese peroxide is avoided, and the reducers need not be added. Following are different methods of operating:

Example 1.—One hundred kilogrammes of amylaceous matter are placed in a wooden tub lined with lead, and 130 kilogrammes of a 2 per cent solution of permanganate of potash added. The mass is left at rest for about twelve hours, while stirring frequently. Gradually, a precipitate of manganese peroxide is formed, which is removed at the close of the reaction by acidulating with sulphuric acid and decoloring with a solution of bisulphite. By washing with water, the starch is freed from the acid and the manganese salts, and dried at a low temperature. By employing permanganate of potash in larger quantity, for instance 130 kilogrammes of a 3 per cent solution, the reaction is more rapid. If, on the contrary, a smaller quantity of permanganate is employed, the reaction takes place more slowly and less thoroughly.

Example 2.—One hundred kilogrammes of amylaceous matter are washed in 130 kilogrammes of a solution of caustic soda of 0.8 per cent at a temperature of about 30 deg. C.; 35 kilogrammes of a solution of permanganate of potash of 8 per cent are added. At the end of twelve hours, during which time the mass must be stirred several times, the reaction is terminated. Then the process continues as in the preceding example.

Example 3.—One hundred kilogrammes of amylaceous matter are put in 130 kilogrammes of sulphuric acid of 15 per cent, preferably at a temperature of 32 deg. C. To the deposit of acid starch, 25 kilogrammes of a solution of permanganate of potash of 8 per cent are added. The starch, which at first has a brownish red color, is bleached perfectly in two hours, and the reaction is then complete. By washing with water, the starch is freed from the acid and the manganese salts, and then dried at low temperature.

The proportions that have been mentioned are suitable for any kind of starch. Instead of permanganate of potash, equivalent quantities of other permanganates may be employed; as, for instance, permanganate of soda or permanganate of lime.

In aqueous solution and in contact with iodine tincture, the soluble starch prepared in this way assumes a dark blue coloration, without there being a precipitation of the iodized starch not dissolved. The soluble starch does not contain dextrine and glucose. Its reaction is neutral, and it is not hygroscopic. In solution it readily penetrates textile fibers, and it affords, after drying, a dressing quite resisting, elastic, and brilliant, which does not disappear under the action of the moisture of the air, as happens when dextrine and other similar substances are employed.

This process of preparing soluble starch has the great advantage, over known processes based on different principles, of yielding a product of which the solution may be better preserved than solutions prepared with other preparations of soluble starch; the solution remains liquid after a repose even of several days, and is scarcely clouded in that time. This is an industrial result of importance, for in this way the last drops of the solution can be employed. Solutions do not congeal in the receivers, and as they flow readily, may be advantageously utilized for cold dressing.

Soluble Starch by the Wotherspoon Process.—Watts' Chemical Dictionary states that glacial acetic acid, heated in a sealed tube with starch, will convert the latter into soluble starch. This fact does not appear to have attracted attention or to have been noticed in any other work. But it is now utilized in a patent which has been taken out in France.

The soluble starch is produced by means of certain monocarboxylated organic acids. Previously, certain organic acids have been proposed for replacing mineral acids in known processes for hydrolyzing the starch by heating with water and a small quantity of acid or alkali. But the present process does not bear on the aqueous hydrolysis of starch. In fact, it is better realized in the absence of water, although its presence does not essentially interfere with the success of the process. It has been found that with certain of these monocarboxylated acids, a different product, chemically speaking, can be obtained, than those heretofore produced by completely dissolving in boiling

water, in the form of a clear liquid not gelatinizing or separating even after a considerable time. The following are methods by which the process is effected:

1. Starch, preferably fecula or potato starch in fine powder, is dried at a temperature of 80 deg. to 100 deg. C. Into a receiver, or rotary converter, having a steam jacket, the starch is introduced, and glacial acetic acid added in the proportion of about one-half or one-third in weight of the starch. The proportion of acid may be reduced, and only 10 to 20 per cent of the weight of the starch employed, if it is introduced by a suitable sprayer on the starch in a cylindrical mixer. The receiver is closed and made to revolve slowly, or the mixture may be stirred by means of an agitator, after which the steam is introduced in the jacket and heat continued for one or two hours, during which the receiver or agitator must continue to revolve slowly. In this operation, or when it is finished, the receiver may be put in communication with a condenser, in order to allow of the elimination of the acetic acid in excess by distillation, with a view to its ulterior use. The starch is allowed to cool, and is washed with cold water. It does not differ in appearance from ordinary starch, and the drying and finishing may be accomplished in any way.

Instead of employing acetic acid in the manner indicated, it may be used in the state of vapor, so as to obtain it on treating an acetate with a non-volatile acid in a separate receiver, and introducing it in this state into a mixture containing dry starch, until this has absorbed from 10 to 20 per cent of its weight. This mixture is afterward introduced into the converter, which is heated in the manner indicated above.

2. In a cylindrical mixer, dry starch is mingled by means of a sprayer with about 10 per cent of its weight of formic acid of from 60 to 90 per cent. It is then introduced into the converter, and treated as in the preceding example for from one to four hours, according to the degree of conversion desired; that is, according to the wished-for degree of solubility of the starch in hot water. When the product has been cooled, it is washed with cold water and dried. Or else the acid retained in the starch is neutralized by adding a suitable alkali, such as borax or an alkaline carbonate.

When formic acid is made use of, it is sometimes found that the starch swells considerably. In this case, a neutral dehydrating substance may be added. For instance, the formic acid may be mixed with an equal volume of commercial alcohol.

In the operations anhydrous substances, or those essentially anhydrous, may be employed. If no importance is attached to the time of the conversion, aqueous organic acids, of the category indicated, may be made use of, provided the acid is in such quantity that its specific action will predominate over the hydrolyzing action of the water. In this case the operative method is the same in practice. If, for example, an excess of aqueous solution of nitric acid, of a proportion of 20 to 30 per cent of acid is mingled with the starch and if afterward the liquid in excess is eliminated by means of a turbine and the mixture dried in the oven, the conversion may take place in forty or fifty hours. A similar result is obtained if the quantity of aqueous acid is limited to what is necessary for the production of a moist powder, and if the mixture is accomplished by means of a sprayer. The lactic acid may be replaced with acetic acid of 20 to 40 per cent or formic acid of 10 to 20 per cent.

When use is not made of an absolute acid, the diluent employed is not necessarily water, which on heating causes the swelling of the starch grains. It may be alcohol, or any other volatile liquid which does not occasion this swelling at the temperature of the treatment. In this case, the operation may be conducted in a closed vessel, and the diluent collected by distillation. When an aqueous acid is employed, certain saline solutions may be added, such as a solution of sodium chloride, to prevent the swelling of the grains. When alcohol or a saline solution is employed, the operation may be conducted at a higher temperature and will consequently require less time.

Purification of Starch by the Varley Method.—This process for purifying the starch of wheat, rice, maize, and other grains, and of potatoes and other feculæ rests on the discovery of the special effect produced on these bodies by the action of alkaline hypochlorites, employed in a rational manner and in well-defined proportions. These effects consist essentially in the rapid elimination of the gluten and other nitrogenized substances.

After treatment, the pure starch may be separated readily. The bleaching and antiseptic action of the hyposulphites is also exercised usefully, as in the ordinary applications of these salts, and washings with water are sufficient for the production of the starch in a state of great purity.

According to the nature of the products to be treated, the alkaline hypochlorites are employed in variable quantities. They are made to act on the starches and feculæ charged with nitrogenized products after sifting and deposition. The crude starches collected are diluted in water, to which hypochlorite of potash, of soda, of alumina, or other salt, has been added. The proportions of hydrochlorite should be varied according to the purity of the products treated. For limits of the quantity of the reagent, 1½ to 4½ per cent of the weight of the starch to 15 volumes of active chlorine may be given. The liquor charged with the starch in suspension should be brought to 12 deg. B.

For allowing the reagent to act and to remove from each grain of starch the impurity contained, it is proper to keep up agitation for several hours. Afterward

the liquid is left at repose and then decanted, which separates out the impurities dissolved and in suspension.

The starch is washed several times with pure water, and after each washing allowed to deposit, and the water removed by decantation. The starch is finally collected on a sloping surface.

The treatment of starches and feculæ by means of hypochlorites produces, therefore, without other reagent, purified starch; for, besides the separation of the glutes and other nitrogenized matter, which constitutes the essential object of the process and characterizes the new application of the hypochlorites, these exercise advantageously their known bleaching and aseptic action, rendering all fermentation impossible. Nothing remains to be done except successive washing, to eliminate the excess of reagent with the impurities which it draws off.

HAY FEVER—A NEWLY-DISCOVERED REMEDY.

PROF. W. F. DUNBAR, director of the State Hygienic Institute at Hamburg, recently delivered a series of lectures on hay fever before the Hufeland Society, which were reproduced in the Berlin Clinic Journal. The Frankfort Zeitung recently published a lengthy article in which Prof. Dunbar's lectures were freely used, a translation of which article is furnished by Consul-General Guenther. The Frankfort Zeitung says:

In his deductions, Prof. Dunbar confirms the fact that the pollen-toxin is a tox albumen. By means of the toxin solution it can be proven that a single grain of pollen contains enough toxin to produce intense irritation in very sensitive hay-fever patients. In this way the objection that grains of pollen could not be the cause of hay fever, because too few were contained in the atmosphere, is disproved. During the hay-fever time, that is, during the flowering time of the grasses, immense amounts of efficient pollen have been found in the air. Up to four millions can be deposited upon one square meter within twenty-four hours.

Most people are not susceptible to the influence of pollen toxin, but for hay-fever patients it is an extremely strong-acting poison. They are susceptible to the action of the most minute doses of the same. On account of this fact Prof. Dunbar remarks: "I feel justified in stating that the hay fever appearing in the spring is an etiological disease. The same is the case with the American fall hay fever, only in this the cause is found in the pollen of ragweed and goldenrod." Prof. Dunbar endeavored to find a specific antitoxin. He describes the many experiments to obtain an antitoxin from animals, and reports that the blood serum of some animals showed clear antitoxic effects within a few weeks. A mixture of pollen toxin and the serum prevented the irritating effects of the former. Prof. Dunbar continues:

"For therapeutical purposes, the blood serum of horses treated with pollen toxin is naturally not applicable as soon as the first signs of the formation of antitoxin are noticed, but it can only be considered when it has attained a certain strength. For prophylactic purposes a serum of only a small amount of antitoxin would as a rule suffice. Apparently with only a few patients a systematic course of prophylactic treatment could be counted upon, and therefore the antitoxin will have to be employed in practice, as a rule, of great strength. In course of time it has been possible to produce a relatively very efficient antitoxin. The antitoxin which is manufactured by the firm Schimmel & Co., of Nilitz, near Leipzig, upon a large scale, has received the name Pollantine. Its manufacture is under constant control of the veterinary university of Leipzig. The subcutaneous use of antitoxin seems to be precluded as many hay-fever patients possess an idiosyncrasy against normal horse serum. After it has been ascertained, meanwhile, that the anti-toxin is completely united with globuline, experiments are being made to prepare a serum which is also suitable for hypodermic injections.

"I do not consider such a serum as absolutely necessary. I consider it, however, as a very special advantage of the hay-fever antitoxin that success is attained without resorting to injection. Hay fever differs from those diseases where, so far, specific antitoxins have been employed mainly in this, that infection takes place not only once and where the infection matter continues to develop in the body, but that for the duration of several weeks the poison floats to the patient without interruption. A subcutaneous treatment would in such a case be very desirable if the patient thereby would be made perfectly insensible to the pollen toxin for a longer duration than, say, of one to two weeks. This does not seem to be possible at this time. I also had to abandon the experiments for active immunization of the hay-fever patients as being wholly unsuitable in practice. Under such circumstances a mode of application had to be found possible for every patient at any time. It was, therefore, a pleasant surprise for me when I could show that the simple application of one drop of the serum to the conjunctiva or into the nasal canal sufficed completely in rendering these main entrances of the poison completely insensible and also to remove irritation already existing.

"I for one, in view of such facts, have no desire for another remedy, for a more simple application can hardly be found. In cases where the nasal canals are entirely closed, the desired end will be attained by applying the pollantine repeatedly to the conjunctiva. It then acts from the lachrymal canal upon the mucous membrane of the nose. If, in addition, a small ball of cotton wetted or sprinkled with antitoxin is in-

introduced into the nasal canal most afflicted, it can be made perfectly free again in the course of about half an hour, and then the treatment can be applied to the other side. It appears to be very judicious, during the worst days of the hay fever, to soothe the mucous membranes of the nasal canals, and to treat them prophylactically by alternately closing the nasal canals by means of cotton.

"A further improvement of the hay-fever remedy was obtained by pulverizing it, a form in which it is not susceptible to bacteriological decomposition. Sugar of milk is the means to easily dissolve it again, as powdered antitoxin irritates the mucous membrane mechanically. Numerous patients who used the antitoxin in strict conformity with the prescribed use, consumed during a whole hay-fever season only about 3 grammes (about 50 grains) of the powdered remedy in order to be entirely free from attacks. Further remarks apply to the details in using antitoxin. From them it appears that judgment and a certain amount of skill is required to use it correctly.

"But anyhow many hay-fever patients use it successfully, as proven by statistics of Dr. Luebbert, according to which, of 505 patients, 299 (59.20 per cent) use polantine with absolutely favorable results—that is, they were free from attacks during the whole period—143 (28.39 per cent) used the remedy with partial and 63 (12.5 per cent) without any success. It is to be hoped that the results will become more favorable yet with growing and expert use."

A CONVENIENT CAMERA.

By the Late GEORGE M. HOPKINS.

WHILE it may be too early to say the old-time plate-holder camera has had its day, it cannot be denied that magazine cameras of various kinds are superseding the old-fashioned camera, especially among tourists and others who desire to accomplish a great deal photographically in a very short time. The magazine camera is in photography what the Gatling gun is in warfare. It enables the operator to not only secure a great number of subjects, but it often allows him to get a view which would be lost if the plates were to be changed by the clumsy device of the ordinary plate holder.

The low price and good quality of plates and cut films contribute in no small degree to the success and popularity of the magazine camera. There is, however, still a bar to its very general use; that is the high price at which these instruments have been held. As their construction has been somewhat complicated, and as good workmanship is necessary to insure accuracy and reliability, the cost of manufacture has been so great as to warrant existing prices.

The engraving represents a magazine camera which is reliable in its action, and at the same time so simple that its construction is quite within the range of the amateur or ordinary mechanic.

A plate holder or kit is required for each plate or

in the holder. In the face of the holder at the upper corners are formed notches for receiving the nibs of the hooks which are used for changing the plates.

The camera box is divided by a vertical partition into two compartments. In the front compartment is located the lens and shutter, while the rear compartment is subdivided into two similar chambers by a horizontal partition, which extends toward the verti-

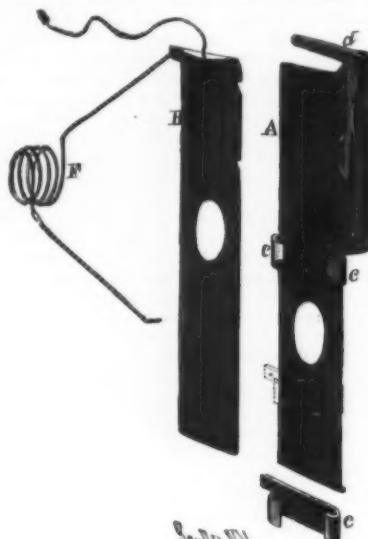


FIG. 4.—THE SHUTTER.

cal, leaving a space which is sufficient to allow the holder lying in contact with the vertical partition to be transferred from the upper chamber to the lower one.

To the rear end of the camera box—which is removable—is attached a pair of pillow springs, which hold the plate holders in the two chambers in contact with the vertical partition. To the end of each spring is attached a follower, which bears against the plate holders. The upper follower has square edges all around; the upper edge of the lower follower is beveled in the same manner as the plate holders.

The vertical partition has opposite the lens a rectangular opening, through which the plate is exposed, and in the vertical partition are formed grooves about three-sixteenths inch deep and wide. In the bottom of the box, opposite these grooves, are formed mortises, for receiving the U-shaped shifting rod, which slides in the grooves. The upper ends of these rods are reduced in thickness, and bent rearward slightly to

It will be seen that the magazine may be made for any number of plates.

The lens in the camera illustrated is a wide angle achromatic of short focus. It is fixed at such a distance from the plate as will enable it to cut a clear, sharp image at a distance of eight feet. No focusing mechanism is provided, as it is found that better results can be secured in a camera of this kind by having the lens in a fixed position. The lens tube is provided with a revolving diaphragm located between the lenses.

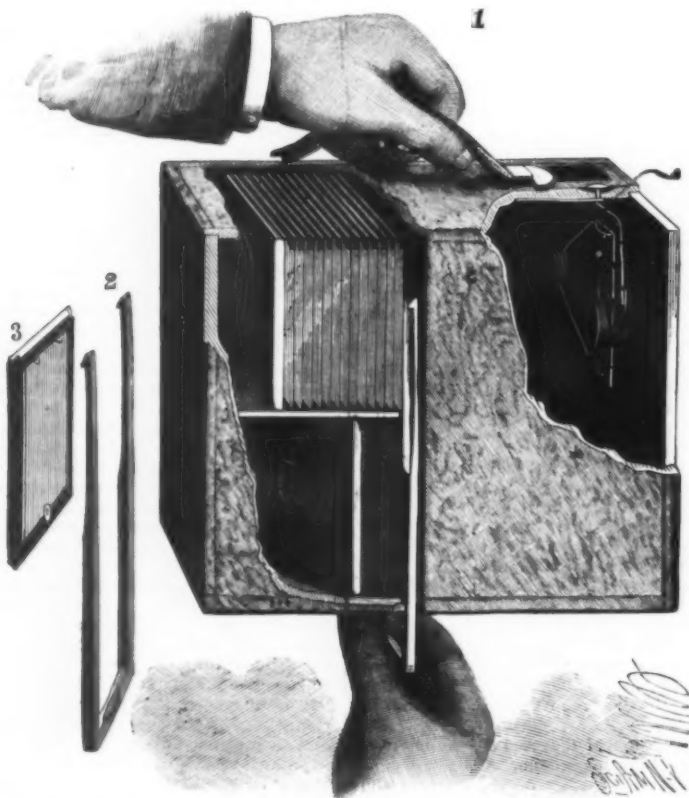
Lenses of this kind, suitable for hand cameras, can be purchased from the dealers with or without a shutter. A very simple and efficient shutter is shown in Fig. 4. It is inserted in slots formed in the lens tube, behind and very near the diaphragm. The narrow end of the plate, A, forming the fixed portion of the shutter is provided with ears, C, which act as guides for the slide, B. A clip, E, placed on the lower end of the plate, A, guides the lower end of the slide, B. It is held in place by a lip on the lower end of the plate, A. The plate and the slide are each provided with a circular opening a little larger than the largest aperture of the diaphragm.

To the plate, A, is pivoted a spring-pressed trigger, D, which engages the notches in the edge of the slide, B. One end of the spring, F, is inserted in the plate, A, the other end being attached to the slide, B. The upper end of the slide, B, is bent over and perforated to receive a stout string, which extends through the top of the camera and is used for setting the shutter.

To the inner surface of the camera top is attached a flat spring, the free end of which projects over the horizontal arm of the trigger, D, and is provided with a button extending through the camera top. By pressing this button the trigger is operated and the slide, B, is released. As the slide is carried downward by the spring the holes in the slide and plate, A, coincide for an instant, thus making the exposure. To change the diaphragm it is necessary to open the front of the camera. To prevent the exposure of the plate a swinging door (not shown) is provided, which closes the opening in the vertical partition, preventing the access of light to the plate. For time exposures the shutter is set open by catching the trigger in the middle notch and using the cap. The speed of the shutter is varied by using springs of different strength.

THE MULTIFARIOUS VARIETIES OF MAN.

UNTIL within a few centuries, most of the fire-making folk remained isolated, partly because of intervening seas, chiefly because of intervening gulfs of faith and custom; though some tribes were united in confederacies in which the chief bond was similarity in belief, the next similarity in speech, and the next similarity in work and industrial standards. In North America there were at the time of exploration some 1,200 or more tribes speaking some seventy-five totally distinct languages, each in several dialects; some of these were united in confederacies, like the Iroquois or Six Nations, and the Dakota or Seven Councilfires, and others lived in an inchoate feudal system, like the Montezuma group of Mexico; some tribes traced kinship in the female line and gave little thought to paternity, while about an equal number (including many of the wanderers and the most advanced sedentary folk) rested their social laws on paternal kinship; while the food-sources, implements, customs, and habits varied first with local peculiarities of habitat and in less degree with ancestral customs and migrations—the range running from corn-growing dwellers in stone, adobe, and palm-wattled houses in the southwest, to hunting and fishing folk living in birch-bark wigwams in the east and thence to walrus-hunting occupants of snow-houses in the north and back to the buffalo hunters of the plains lodging in skin tipis in summer and earth-houses in winter, and thence to the salmon fishermen in single-log boats and hewn-slab houses (both consecrated unto carved and painted totems) in the northwest. In South America the fiducial and linguistic, social and industrial varieties were fully half as many; and the range from the stalwart Patagonians of the south to the puny woodsmen of the upper Orinoco, or from the knifeless Guayaquil savages to the aqueduct building Inca kings, was even wider than that of North America. In Africa there were hundreds of tribes, speaking scores of distinct languages, of which some suggest the inconsequent chatter of Kipling's Bandarlog and really express some community of interest and feeling between lowly men and lower monkeys; and the tribes belong to two leading physical types, the shy and secretive aboriginal people of pygmy stature, and their full-size conquerors—sometimes stalwart and strong-limbed and of heroic stature—who long ago overspread the dark continent, bartering in iron and ivory and gold and often in slaves, and still live in a curious condition of mutual toleration and interdependence with the half-tamed little people. In Australia there were at least scores of negroid tribes, or Blackfellows, speaking a dozen or more distinct and notably primitive tongues, in which, as among some of the African pygmies, bird-like clicks and beast-like gutturals and monkey-like chattering served in lieu of well-defined words, if not of entire parts of speech; though timid and generally peaceful, the tribes were often at bloody war, and though varying in physical form and feature, they were much alike in that few could count above five, none above seven or nine, and many stopped at three, in that their marriage laws were the most elaborate known, and in that many of the tribes merged sex-differences by ceremonial and surgical devices. On the miniature continent of



MAGAZINE HAND CAMERA.

film. The holder consists of a hard wood frame a little larger—inside measurement—than the plate or the film holder, with a piece of thin veneer glued to the back. The upper edge of each holder is beveled on the front, while the lower edge is beveled on the rear, as shown in Fig. 3. Two washers or burrs let into the upper part of the frame project into the space which receives the plate, and in a recess in the lower part of the frame is pivoted a button which, when turned transversely, holds the lower edge of the plate

cause the nibs at the ends of the bar to enter the notches in the upper corners of the holder. After the first plate is exposed, the shifting rod is pulled down, thus carrying the plate holder from the upper chamber downward into the lower chamber, in front of the follower, which is forced backward by the engagement of the beveled lower edge of the plate holder with the beveled upper edge of the follower. After the second exposure, the plate holder is drawn down in front of the first plate holder, and so on.

New Zealand dwell a composite people whose physical types were largely welded through similarity in esthetic and industrial and philosophic traits and customs, including the world's most elaborate system of heraldic genealogy in the form of facial tattooing; and in Oceania most of the hundreds of islands and insular groups were inhabited by distinct tribes of two or three dominant physical types, each tribe commonly speaking its own language and pursuing its own special vocations with its own peculiar devices. In Asia there were the world's largest populations in three races, each including divers physical types; even the most homogeneous—the Mongolian—comprised a dozen or more divisions whose differences in speech and customs are not yet fully realized, partly because most of them are dominated alike by a vigorous Manchu dynasty and the terrifying Yellow Dragon; while the northern steppes were ranged by a dozen tribes of varying physique and speech and faith, and the southern plains and foothills and jungles gave homes to literally hundreds of peoples, distinguished by physical type, by speech and faith, by caste, and by distinctive customs or clear territorial limits—and out of this hive of humanity sprang all the great religions the world has known. In the western fraction of the Eurasian land-mass there were, a half-century ago, several scores of tribes varying in physical type from the blond Dane and rufous Viking to the swart Iberian, speaking some dozens of distinctive tongues, adoring the shrines of countless nature-deities, and garnering germs of drama and letters and philosophy in the Wall-halla of the north, the Elysium of the south, and the legion lost fanes and faiths of the middle lands. As the centuries sped, the tribes and tongues were partly blent through conquest by Aryan leaders who carried the cult and the color of the Caucasus northwestward, until by the middle of our era the shore-lands of the North Sea region throbbed with the most commingled blood and the most complex culture of the globe—then the human blood spanned the straits and rose pent in Britain to flow out in streams of compelling vigor, bridging all seas and reaching the remotest lands of the earth. All these—of the Americas and Africa, Australia and Oceania, Asia and Europe—are among the peoples whose multifarious resemblances and differences appeal to every observer. They are alike in that all are fire-makers and so control thermic force for the weal of their kind through conquest over other nature; and with this suggestion of force as the primary factor in human affairs, the apparent chaos of humanity falls into order—for all are controlled by a few types of law, i. e., of human force directed to human ends. The simplest type of law is that of control of the maternal family, under which the mother protects and directs her own children, appealing when needful to her own mother's strongest offspring, i. e., her eldest brother; and this was the law of the less-developed aborigines of the Americas, Africa, Australia, Oceania, and Asia. More comprehensive is the law of control of the paternal family group, in which the physically stronger father guards and guides his own children and their offspring and dependents and those of his younger (i. e., weaker) brethren; this law befits militancy and nomadic habit and the pastoral condition, and prevailed among the more advanced aborigines of America and Africa and many of the peoples of Oceania and Asia. Still more comprehensive is the law of control of tenure; in arid lands, where the chief values inhere in springs and wells with adjacent lands, the control is essentially territorial, and in the east Mediterranean region the law gave demos and urbs—i. e., the artificial group and the ancient city; in fruitful lands, where the chief values inhere in occupations and products and goodwill, the law is essentially industrial, and in India yielded caste, and elsewhere trades and guilds, i. e., overlapping artificial groups; and in broken country (including archipelagoes) the control is partly territorial and partly industrial, and in eastern Asia, most of Europe, and much of Oceania, the law produced the province—i. e., the more or less independent region of interdependent interests; and everywhere the basis of the law was economic and proprietary, and its observance reacted on the mind in such manner as to awaken recognition—especially in Greece and Rome, and Kong (China) and more especially in Palestine—of the correlative interests of neighbors. While the law of control of tenure rose above the law of control of kindred in principle, the two ran together in practice, so that the demos and urbs, caste, the province, and the nation into which the urbs and province grew, were long controlled by family lines. Most comprehensive in applicability though simplest in ethical essence of all the fundamental types of law is that of control of the individual for the common good; in spirit this law rises above consanguinity and proprietary bonds and gives origin to government of the people, by the people, for the people. Thus, just as man, the fire-maker, rises above lower nature through control of external force, so does man, the law-maker, rise in successive groups above the lower of his own kind through control of the movements and motives reflecting his own internal force; and viewed in the light of law, the apparent chaos of uncounted thousands of the world's tribes and peoples, speaking unreckoned hundreds of tongues and pursuing innumerable vocations, is readily reduced to order.

The Vegeto-Animal Glue.—This preparation, which is claimed to be of good preservation, and not to change color, is composed as follows: fecula, 50 parts; soda in solution, 10 parts; strong glue, 12.5 parts; nitric acid, 10 parts; water, 17.5 parts. Total, 100 parts.

ANTS THAT WEAVE WITH THEIR OWN LARVÆ.

By DR. REH.

In the year 1890 Ridley published a description of an East Indian ant, *Oecophylla smaragdina*, which, he asserted, made its nest of leaves fastened together by threads spun by its own larvæ. Although this statement has been confirmed by several observers it has not been generally accepted as correct. The assertion that one animal could use another—even its own larvæ—as a tool was so directly opposed to the accepted laws



FIG. 1.—REPAIRING A TORN NEST OF THE EAST INDIAN ANT, *OECOPHYLLA SMARAGDINA*.

Five workers, on the outside, draw the edges of the fissure together, while three, on the inside, "sew" with larvæ.

of animal psychology, that it, apparently, could not be true.

Now, however, all doubt has been removed by the recent observations of F. Doflein on *Oecophylla smaragdina*, and those of E. Goeldi on a Brazilian species of ant. The following is an abstract of Doflein's paper in the Biologisches Zentralblatt, August 1, 1905:

The nests are formed in trees by bringing together the living leaves of several twigs and fastening the edges of the leaves together with a silky mass, which also fills all the interstices and openings between the leaf-stalks, etc. Inside of the nest the leaves are covered with aphides, kept evidently as "cows" to furnish the "honey dew," or sweet secretion, of which ants are so fond. In Ceylon, Doflein had an opportunity of observing accurately the weaving operations of the ants. For this purpose he tore a nest slightly. Thousands of ants instantly swarmed out from the fissure, as if to repel the enemy.

Soon, however, a small troop of ants detached itself from the main body, and arranged itself in a very remarkable way in a straight line along the fissure (Fig. 1). Standing on one side of the opening and holding on to the leaf with the claws of all six feet, the ants seized the edge beyond the fissure with their mandibles and walked backward, very slowly and carefully, thus gradually bringing the two edges together. It was a curious sight to see the insects working together, with their bodies parallel to each other.

They continued to hold the leaves together while other workers cleared away the wreck of the ruptured tissue, which they tore into shreds with their mandibles, and carried piecemeal to an exposed part of the nest, where they disposed of the fragments by waiting for puffs of wind and then opening their jaws wide. This work occupied nearly an hour. Then came a sudden and violent gust of wind, which swept away the ants that were keeping the fissure closed, and destroyed the result of their labor. But the ants were not discouraged by this failure. Again a long row of workers was formed along the fissure, and after another half hour's pulling the edges were again brought nearly together. Now from the back of the nest came several workers, each of which held a larva in its mandibles.

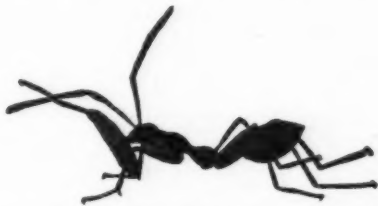


FIG. 2.—WORKER HOLDING A SPINNING LARVA IN HER MANDIBLES.

Straight to the break they came, and clambered around and under the row of pullers. They held the larvæ so tightly that the latter appeared somewhat constricted in the middle. Perhaps the pressure so exerted is a necessary stimulus to the silk-producing glands. The weavers, or sewers, worked on the fissure from the inside of the nest, carrying the larvæ with their pointed heads directed upward and forward, and moving them from one side of the fissure to the other, pausing an instant at each side, apparently to fasten the thread by pressing the head of the larva upon the leaf. The threads spun by the larvæ are too thin and transparent to be visible, singly, to the naked eye; but as the work progressed the fissure was seen to be gradually closed with a fine silken tissue. Each weaver first moved its larva back and forth a number of times in the same spot. In this way retaining cables were soon established at several points, which evidently relieved the strain on the pulling ants. Afterward the weavers

moved about and laid threads in all directions. There can be no doubt that the ants actually used their larvæ as distaffs and, at the same time, as shuttles. Working close together, they were able to cross their threads, and thus to form a web firm enough to be cut with scissors.

Yet Bethe calls ants "reflex automata"!

THE PRESENT POSITION OF RADIO-ACTIVITY.*

By FREDERICK SODDY, M.A.

THE address commenced with the consideration of three fundamental conceptions. The first and oldest is the atom, the unit or smallest particle capable of separate existence, of the simplest forms of matter or chemical elements. The essential feature of Dalton's conception was that the atoms of the same element are all exactly alike in mass and every other property, but are recognizably different from the atoms of any other kind of element. The statement will be found in textbooks of chemistry written long before the recent discoveries were foreshadowed, that if it is ever found possible to transmute any one kind of atom, that is, any one kind of elementary matter, into any other kind, there is little doubt that the same means would be sufficient to transmute or decompose the other elements.

The second conception is the electron, and this, although by origin an electrical conception, is in reality a material conception no less than the atom of matter. The electron could be defined as the smallest existence known capable of isolation and of free movement through space. It is a definite amount of "charge" of negative electricity, being the smallest possible amount known to exist for electricity, no less than matter, has been shown to consist of discrete particles or units, and not to occupy space continuously. Unlike the atoms of matter, only one kind of electron is known, consisting of the same amount or charge of negative electricity with identical properties in all its various manifestations.

It is certain that each atom of matter contains in the normal condition at least one electron, which it is capable of losing, and conversely may unite with at least one electron more than it normally possesses without deep-seated material change. An atom with one or more electron less than it possesses in the normal state is positively charged and is often called a positive ion. Similarly an atom with one or more electron in excess is a negative ion.

The third conception is the universal ether, in the sense of a medium of definite properties extending continuously between the discrete or separated particles of matter. Our definite knowledge of the properties of the ether dates from the determination of the velocity of light through intra-stellar space. The medium is capable of transmitting disturbances at a definite speed, namely, 3×10^{10} centimeters per second. Recent advances all show that the ether is only capable of transmitting disturbances at this one speed and in one way, and that all the effects which travel through the ether—light, X-rays, and Hertz waves—are various manifestations of essentially the same type of disturbance in the ether.

Let us now consider the case of an electron moving through the ether unimpeded by matter. This is very nearly realized in the Crookes tube. When matter is negatively electrified *in vacuo* to a very high degree, as in the case of the cathode of an X-ray tube, the electrons may be regarded as accumulating in the cathode until their mutual repulsion is so great that some escape. The moment the electron is free to move outside the cathode it experiences a very great repulsion from the electrons remaining in the cathode, and consequently it moves away along the line of the repelling force. Its velocity continues to be positively accelerated until it has passed without the sphere of influence of the repelling cathode, and then it travels at uniform velocity through the empty tube until it meets the anti-cathode placed as an obstacle in its path. On striking this its velocity is destroyed, and the electron is brought to rest. The electron at rest constitutes a simple charge or electrostatic phenomenon, but the electron in motion is in every sense a current of electricity or electro-magnetic phenomenon. A current of electricity cannot flow without endowing the medium through which it flows with magnetic properties, and this medium then possesses magnetic energy. Thus the medium through which it moves at first possesses no magnetic energy, then it acquires magnetic energy, and then it loses its energy. So that we see at once that an electron cannot move from rest without receiving some definite amount of energy, and it cannot stop without again giving up the same amount. So that even an electron, disembodied from matter, and consisting of an electric charge only, must possess the fundamental property possessed by matter, of resistance to change of motion, or inertia.

The various disturbances, light, X-rays, and Hertz waves, are now known to all to have a common origin in the acceleration or variation of the velocity of electrons, and all to travel at the same speed. If an electron moves at constant speed in a closed curve within an atom it will give rise to the regular periodic or rhythmic disturbance we call light.

At the anti-cathode of a Crookes tube we have an irregular shower of free-flying independent electrons. X-rays thus partake of the character of irregular pulses, having a relation to light very analogous to that between a noise and a musical note in acoustics. But the suddenness with which they are stopped causes the thickness of the pulse, which corresponds to the wave-length of a light-wave, to be extremely

* Presidential address to the Roentgen Society.

small, and this probably accounts for their great penetrating power.

The Hertz waves of wireless telegraphy are a type of the opposite extreme. The electrons here oscillate along paths of perhaps several meters in length, and in consequence the wave-lengths, instead of being measured in millionths of a millimeter, as in the case of light where the orbits are of atomic dimensions, attain to dimensions appropriately measured in meters.

Turning to the phenomena connected with the radio-elements, the speaker remarked that the discovery of the natural radio-activity of matter by M. Henri Becquerel would celebrate its decenary this year.

Two out of the three types of rays emitted by the radio-active elements, known as the beta- and gamma-rays, are substantially of the same nature as those emitted by a Crookes tube. Thus the beta-ray is the familiar electron in motion and corresponds with the cathode-ray, while the gamma-rays result from the beta-rays in much the same way as the X-rays result from the cathode-rays. The difference is that the X-ray bulb acts under the action of a constant supply of external energy and ceases to work the moment the supply fails, whereas the radio-elements are entirely independent of external stimulus or supplies of energy. In the resemblance between the beta-rays and gamma-rays and the cathode-rays and X-rays of the Crookes tube there is an important difference. The electron which constitutes the cathode-ray travels ordinarily at a speed about one-tenth that of light, whereas the beta-rays of uranium travel with a speed about seven times greater. Like the cathode-rays, the beta-rays are deviated by a magnet, but with much greater difficulty. Some of the beta-rays of radium have been shown by Kaufmann to have a velocity 95 per cent of that of light. It was rightly considered a great experimental feat, so easily are the cathode-rays absorbed, even by the thinnest screen of matter, when Lenard for the first time succeeded in obtaining the cathode-rays outside the Crookes tube by inserting a tiny aluminum window just thick enough to stand the pressure of the atmosphere, and thin enough to allow a small fraction of the cathode-rays to pass through unabsorbed. Rutherford has given the thickness of aluminum necessary to absorb one-half of the beta-rays of average penetration power as 0.5 millimeter. So, too, with the gamma-rays; these, although strictly speaking X-rays, are so penetrating that in passing through the hand, for example, there is so little absorption that the bones cast practically no shadow. The beta-rays are not penetrating enough, while the gamma-rays are too penetrating for radiography. Eight centimeters thickness of aluminum are necessary to absorb half the gamma-rays, while Rutherford has shown the effect on an electroscope of the gamma-rays from 30 milligrammes of radium bromide after passing through a foot thickness of iron.

An instructive difference exists between the gamma-rays and the X-rays. In the Crookes tube the electrons are gradually started and suddenly stopped, and although theoretically X-rays should accompany both start and stop, the latter only are penetrating enough to get outside the glass tube. In the radio-elements the beta-ray electron is suddenly started, and we have seen that it is so penetrating that even the densest matter cannot suddenly stop it. But the acceleration experienced by the beta-ray electron expelled in the disruption of the radio-atom is the most sudden known, and in consequence the gamma-rays are by far the most penetrating type of X-ray known. The beta- and gamma-rays invariably accompany one another, but together constitute only a small and comparatively insignificant fraction of the total energy emitted in the form of rays by the radio-elements. Rutherford recognized very early that there exists in the radiation another type, which he called the alpha-ray, and this type comprises all but a few per cent of the total energy radiated. The alpha-ray is scarcely able to penetrate the thinnest sheet of paper, mica, or aluminum, and is completely absorbed in 7 centimeters of air. After prolonged study he succeeded in deviating it very slightly by the action of a magnetic field, and showed that the deviation was in the opposite sense, and only about one-thousandth as great as that which would be experienced by a cathode-ray under similar circumstances. He concluded that the alpha-ray was a radiant atom, minus an electron, or positively charged, and that it travels with a speed about one-tenth of light. The most recent results point unmistakably to the conclusion that the particle is, in fact, an atom of the element helium. Now, the energy possessed by a radiant atom of helium is more than 1,000 times that possessed by a cathode-ray electron traveling at similar speed. But it is far more easily stopped by matter. Indeed, the surprising thing is that the alpha-particle should penetrate at all. Some very recent most interesting results of Prof. Bragg, of Adelaide University, have shown clearly the nature of the process when a radiant atom strikes a stationary one "head on." The radiant atom passes on its way through the other none the worse for the encounter, much as two solar systems traveling at high speed in opposite directions might pass through each other.

The alpha-rays are the cause of the scintillations of the spintharoscope, each individual alpha-particle producing a flash of light on impact with the zinc blende crystal. The alpha-rays also cause by far the main part of the ionization of gases, and therefore of the discharging action of the rays on a gold-leaf electroscope. The photographic and fluorescent action of the rays are mainly due to the beta-rays, while the feeble gamma-rays are most readily observed by their fluorescent action. Polonium is unique among the radio-elements in giving only alpha-rays.

These facts began to be generally appreciated after the separation of radium from pitchblende by M. and Mme. Curie.

The recognition that the expulsion of the alpha-, beta- and gamma-rays is the mere outward and visible sign of a deep-seated material change continuously occurring within the atoms of the radio-elements began with the clear elucidation of two other phenomena exhibited by certain of the radio-elements—namely, their power of producing a radio-active emanation, and the power of the latter to impart radio-activity to surrounding objects. These powers are shown by thorium, radium and actinium, but not by uranium or polonium. In addition to their radiations, each of the elements first named continuously produces what has now been clearly shown to be new radio-active gases generally called "emanations." The thorium emanation was first discovered by Rutherford, and the recognition of the other two quickly followed. The production of this emanation from the radio-element has been proved to be produced in the same constant amount under all circumstances. Under some circumstances the production is more obvious than in others, for certain of the solid compounds possess the power of retaining and storing up the gaseous emanation and so preventing its escape into the air. This does not occur with a solution. These emanations have all the same essential features, but differ among themselves greatly in detail. The radio-activity of the emanation continuously decays with time after its production from the radio-element according to a regular geometrical law. The activity of the emanation from actinium decays to one-half of its initial value after the lapse of only four seconds. The same occurs in the case of the thorium emanation in about a minute and for the radium emanation in four days.

All three emanations possess the extraordinary power of imparting to inactive solid objects in the neighborhood a new and distinct type of temporary activity. This "imparted activity" decays also according to regular laws, which are characteristic and distinctive in each case for the different elements from which they are derived. This process has been elucidated and shown to be due to a change occurring in the gaseous emanation. Gradually and continuously it turns into a new type of radio-active matter, non-volatile and so depositing itself as a film upon any solid object available. The films are invisible and unweighable, and are only known by their activity. Nevertheless, if such a surface rendered active by exposure to the emanation is scrubbed with sand-paper, the film is removed and the activity is then found on the sand-paper.

In consequence mainly of these and allied phenomena the view was put forward in 1902 by Prof. Rutherford and Prof. Soddy that the radio-elements were in a state of continuous and spontaneous change, capable of an exact quantitative expression, and that the emanations and allied bodies were the products of these changes.

We have seen that radio-activity is a property intrinsic to the element, and, therefore, to the atom or smallest part of the element. The radio-elements possess the heaviest known atoms. If the lightest, hydrogen, is taken as unity, uranium is 238, thorium 232 and radium 226, while the next heaviest known are the inactive elements bismuth 208, and lead 207. The element helium is the second lightest known and its atomic weight is 4. Now, if the alpha-particle is an atom of helium, the expulsion of one alpha-particle from an atom of radium will reduce its atomic weight from about 226 to 222. This must, therefore, be a new atom and represent an unknown element, for we have seen the nearest known element has the atomic weight 208. Now, you are aware that the chemical elements run in families. Radium, for example, is the missing "big brother" of the alkaline-earth family of elements, which consists of three elements, calcium 40, strontium 87, and barium 137, and chemically radium is an almost exact copy of its nearest relation, barium. Helium, in turn, is the lightest member of a family of gaseous elements, exactly similar in chemical nature. The family forms the well-known group discovered by the joint labors of Lord Rayleigh and Sir William Ramsay. The series runs, helium 4, neon 20, argon 40, krypton 82 and xenon 128. It happens that the heavy residue of the radium atom possessing an atomic weight of about 221, left behind after the expulsion of the light helium atom, turns out to be one of the missing big brothers of helium itself, being nearly twice as heavy as the heaviest (xenon) previously known. It is new, and a gas of the same chemical nature as the others, and is produced at a steady rate from radium, one atom for every alpha-particle expelled. It is, in fact, the radium emanation.

A quantity of radium, although it is sending forth its shower of alpha-particles continuously from year to year, does not grow appreciably less. The most sensitive balance has not yet succeeded in showing any change of weight. Hence it is obvious that although the actual number of alpha-particles and of new atoms of emanation may be, indeed must be, enormous, they only represent an unrecognizably small fraction of a minute amount of radium. The radium atom turns into a new atom, the atom of the emanation, by expelling an atom of helium. If the emanation expels another helium atom another new residue atom of weight 217 will be left. This is the solid form of matter which is deposited as a film from the emanation and is the cause of the phenomenon of the imparted activity. It is called by Rutherford *radium A*, and it also is recognized solely on account of the alpha-particles it expels. So the residue from radium A is another new atom of weight 213; it is called *radium B*. Rutherford, as the result of a series of ob-

servations elucidated with consummate skill, has recently arrived as far as radium F, in the analysis of the later slow changes of radium. But an alpha-particle is not expelled in each case; sometimes it is the beta-ray or electron only, as in the case of the change of radium E into radium F; sometimes no radiant particle is expelled at all, and we have a *rayless* change, as for example when radium B turns into radium C, but then the next change, that of radium C into radium D, makes up by expelling both alpha- and beta-particles. Reverting to radium F we find it also gives an alpha-particle and so must change into a radium G. Now radium F, the seventh successive product of the disintegration of radium, has been shown to be the polonium of Mme. Curie, found by her as a constant companion of radium in the uranium mineral pitchblende. Polonium gives alpha-rays, but no detectable other product. We have at length reached the apparent end of the process. Radium G does not expel either alpha- or beta-particles, and so we have only a theoretical reason for believing it to exist. We can, however, make a good guess as to what radium G is. Counting the total number of helium atoms expelled in the series, we find they amount to five, or a loss of the atomic weight of 20 units, which leaves a residue about 205. Now remembering that the atomic weight of radium is uncertain to at least a unit, and that, if anything, the atomic weight of helium is likely to be less than four, you will see that lead (207) might well be radium G. This is as much as can be said for the moment.

Not only have the chemical and physical characteristics of these intermediate forms of matter produced in the successive break-up of the radio-elements been determined (and they exhibit a strange diversity), but also the period of average life of the atom in each case. This latter is the most characteristic constant by which the numerous forms may be distinguished. It was thus that polonium was shown to be radium G. The average life is got from the rate of decay of the radio-activity. A definite proportion of the total number of atoms present undergoes disintegration per second, and in consequence the number present diminishes after removal from the parent element, and the activity correspondingly decays. Thus, in the case of the thorium emanation, it can be readily calculated that about one eighty-seventh part of the total number of atoms expel alpha-particles and change per second, so that the period of average life of the atom of the thorium emanation is 87 seconds. Similarly, for the radium emanation atom only one five-hundred-thousandth disintegrates per second, so that the period of average life is 500,000 seconds, or 5.3 days.

The older methods of physics and chemistry are useless, except for those forms which exist in quantity. But the newer methods of radio-activity we have seen will succeed in detecting indirectly, on account of its energy-outburst, a single atom.

The second difference between the stable forms of matter dealt with by chemical methods and the unstable forms dealt with in radio-activity is that although there is no limit to the amount of any of the stable elements that can be accumulated and worked with, there is a very important limitation to the amount of an unstable or radio-active element that can be accumulated. For example, the real reason why polonium has never yet been obtained in weighable quantities, although enormous amounts of pitchblende have been worked up for it, is that, unlike radium, the period of its average life is only a few months. Not only, therefore, is there much less polonium in pitchblende than radium, but since the process of separation takes time, it tends to disappear as fast as it can be accumulated.

In any disintegration series where the products steadily accumulate with the parent element, the time will come when the number of each of the intermediate atoms formed equals the number which disintegrate, and then the quantity accumulating does not further alter. The longer-lived forms will accumulate to a greater extent than the shorter-lived forms, but more time will be required in the former case for the equilibrium state to be reached.

Thus, if solutions of radium and thorium are contained in closed bottles, the amount of emanation accumulating in the bottle containing the thorium will reach its maximum in a few minutes, and after that, however long the bottle is kept closed, no more emanation can accumulate, for as much disintegrates per second as is formed per second. But in the case of the radium solution the quantity accumulating will go on increasing daily, and the maximum or equilibrium amount will not be reached until some weeks after the bottle is closed up.

When, however, the end of the disintegration series is reached, since the ultimate product is not changing, the quantity accumulates without limit, and, provided that you are able to wait sufficient time, you will ultimately obtain enough to detect by ordinary chemical analysis. But in most cases centuries would have to elapse for this to occur. Fortunately there is an indirect method of obtaining evidence of the nature of the ultimate products. These processes have been going on continuously during past ages in the earth, so that if we track the disintegrating element to its natural source, the mineral in which it occurs, we shall expect to find there the ultimate products of ages of past accumulation. The short-lived, the long-lived intermediate forms and the final stable products will all exist in recognizable quantity in the natural mineral, as the invariable companions of the radio-element. Thus, long before the production of helium from the radio-elements was established experimentally, helium was clearly indicated as one of the ultimate

products of radio-active change, because it is always found in the minerals which contain the radio-elements, and only in those minerals. We recognize radium, polonium and lead also as constant companions of uranium. We have seen that the average life of the radium atom is of the order of 1,000 years, and of the polonium atom about seven months. If we suppose that radium and polonium are two long-lived intermediate forms in the disintegration series of uranium, the difficulties already raised in connection with the continued existence of these elements at the present time disappear. This view has now been experimentally proved. The growth of radium in solutions of uranium completely freed from it has been observed. In addition it has been established for all the uranium minerals that the ratio between the proportion of uranium and radium is constant. We have seen that radium disintegrates approximately a million times faster than uranium. So that after the lapse of only a few thousand years the radium present in a uranium mineral will attain the equilibrium ratio. As much will disintegrate as is produced from the uranium in its disintegration. As the latter process occurs about a million times more slowly than the former, the equilibrium ratio will be about one part of radium to a million of uranium. The exact amount experimentally found is 0.72 gramme of radium per ton of uranium. The identity of radium G and lead still remains unproved. In addition, the existence of several intermediate forms of long life between uranium (238) and radium (226) has been indicated and they are now being sought for.

The discovery that the proportion of radium in the naturally occurring uranium minerals is a fixed constant, so that if the percentage of uranium is known, the quantity of radium can be calculated, has opened out a vista of new possibilities. A few thousand years hence, the small quantity of radium here to-night will have had its day and cease to be. But if it were then possible to examine the uranium from which it was originally separated, it would be found that a new quantity no less in amount had grown in the interval, exactly as a closed bottle containing radium grows a new crop of the emanation again, however many times the emanation is removed.

The question now arises how far are these principles confined in their application to the radio-active elements, and how far are we justified in extending similar ideas to explain analogous phenomena in the case of the inactive elements.

But this much at least is clear. In the first place it is by no means necessary that the disintegration of an element should be accompanied by an energy-outburst of the kind known to constitute radioactivity. It is because the helium atom is so light compared with the residue atom that it carries with it the greater part of the energy of the explosion, and constitutes itself a penetrating and therefore detectable type of radiation. The most recent work has all gone to prove that it is rather a fortunate chance, so to speak, that the effect we know as radio-activity exists at all. The results of Rutherford have shown clearly that if the radiant particles expelled during the disintegration of the atom were ejected with but slightly less energy than is actually the case, they would neither ionize the air nor affect a photographic plate, nor cause fluorescence, and in fact there would be absolutely no effect capable of detection by our instruments. It is certain that atomic disintegration might be proceeding everywhere around us among the commonest elements at rates comparable with that occurring in uranium, and yet be beyond our utmost powers of detection. Bragg's work clearly shows that the hope of detecting such a change by a gain of charge of the matter is fallacious. Rutherford has also established that changes unaccompanied by detectable radiation ("rayless changes") occur in several cases. These can be recognized if, and only if, they are preceded and followed by changes in which detectable rays are expelled.

Then there is the chemical argument which has been alluded to. Barium is so extremely like radium that it is impossible to believe that they are not similar structures. Radium being the heavier atom has a greater store of internal energy in consequence, but not altogether disproportionately greater. The internal energy of the atoms is merely manifested when the structure breaks up. It is impossible for chemical reasons to suppose that only the radioactive atoms possess this enormous store of energy. The stability of all the atoms to external forces of all kinds, demonstrated by the fact that even now any artificial transmutation is impossible, shows that the energy associated with the internal structure of all atoms must be of a higher order of magnitude than that associated with the molecule.

There is one interesting deduction that can be made at the present stage. Although we cannot yet transmute one metal into another, we know very well why that has never been accomplished. Radium evolves for every gramme weight 100 calories of heat per hour, and since in a year only one-thousandth part changes, it follows that the total energy in the complete disintegration of a gramme of radium must be enormous. It is roughly about a million times that given out by a similar weight of coal burning. If the 30 milligrammes of radium exhibited were all to disintegrate suddenly, the effect produced would equal the explosion of about a hundredweight of dynamite. Uranium in its complete disintegration produces radium, and hence the amount of energy evolved must be as much greater than in the case of radium, as the whole is greater than the part. If we could artificially accelerate the rate at which radium or uranium disintegrates, we should, on the one hand, have achieved

transmutation of a heavier element into lighter ones, and, on the other, have rendered available for use a new supply of energy a million times more powerful than any source at present known. If we succeeded in artificially transmuting uranium there is little doubt that the same means would be applicable to the other elements. Hence the supply of energy would be inexhaustible. But let us see what the old attempt of the alchemist involved. When he was concerned with building up a heavy element like gold from a lighter like silver, he was attempting a most profitless task. The energy absorbed would cost far more than the value of the gold produced. The energy of some hundreds of tons of coal would have to be put into the silver to turn it into gold. But where he was attempting to produce gold out of a heavier element like lead, not only would he have got the gold from the lead, but also a store of energy would have been released in the change of far more intrinsic and commercial value than the gold.

Leaving for a few moments the realm of experimental fact, the speaker made an interesting digression, taking an example from the field of economics and comparing the give-and-take laws governing the question of gold mining, currency and reserves with the broad principles of storage and interchange of energy underlying the phenomena dealt with in the earlier part of the address, and pointed out how great the influence of the field opened up by the disintegration theory was bound to be on the modern thought. It was not necessary that we should ever approach any nearer than we are at present to the application of these new powers and stores of energy to everyday use. The mere future possibility of doing so cannot fail to leave its mark. This was the answer to the question as to whether radium is ever likely to be of use. It might, or it might not, light our lamps or drive our motors. The assured certainty was that if it is ever made to do either of these things, man as we know him would quickly follow his steam engine and dynamo into the museum. At present we had not found how to control the gigantic forces, or affect the tremendous processes we have so lately discovered, and we never may. The important point is that by these discoveries the relations of mankind to Nature have undergone a certain change, and he has caught a glimpse of some latent possibilities within his legitimate destiny which cannot be effaced. Energy is the life of the physical universe. You cannot multiply the existing store by a million and leave things as they were. But the recognition of the internal energy of matter has done this within the progress of the century which has just begun. There is nothing now physically impossible in the engineering feats, which to-day are the marvel of the world, to-morrow being carried out on the million-fold higher scale. A journey to the moon to-morrow may rank with the half-penny car ride of to-day, or the warming of a house with the thawing of an Arctic continent. To-day, so far as any use of the new knowledge is concerned, the one is as impossible as the other, but none would venture to deny to the future the possibility.

SCIENCE NOTES.

The Egyptians were no sailors, but we know that they habitually employed Phœnicians for sea expeditions, while we have the historical record of the Old Testament for their employment by David and Solomon for a like purpose in the Red Sea, and probably far to the south. It is therefore almost impossible to doubt that the Phœnicians were also acquainted with the navigation of the Red Sea and east coast of Africa. Such a voyage as that recorded by Herodotus would in these circumstances be far from improbable. The varying monsoons which had led the Arabians centuries before to get so intimate a knowledge of the east coast as to enable them to find and work the gold fields would be well known to Phœnicians, and the hardy seamen who braved the tempestuous regions lying between Cadiz and Great Britain would make little of the difficulties of the African seas.

Concerning the relations of physiology to public health science, it may be said that here is a field absolutely ripe for the harvest, but one in which the harvesters are as yet very few. Man is a gregarious animal, and mankind is to-day crowding into cities as perhaps never before. Moreover, the industrial and commercial age in which we live is characterized to an extraordinary degree by the sedentary life. Yet the sedentary life is almost unavoidably an abnormal life, or at least it is a life very different from that lived by most of our ancestors. In the sedentary life the maintenance of a high degree of physiological resistance apparently becomes difficult, and if the vital resistance of the community in general is lowered then the public health is directly and unfavorably affected, so that considerations of personal hygiene have a direct bearing upon the science of public health.

Recently Reinke, Benecke and others have focused our attention upon the nitrogen supply in sea water. They find that the organisms *Clostridium Pasteurianum* and *Azotobacter chroococcum* are found in the ooze of sea bottoms; and the suggestion is made that the external but, nevertheless, close association of these micro-organisms with certain marine algae may explain the power of these algae to grow so vigorously in situations in which they are found. The nitrogen supply is probably one of the most important problems relating to the marine algae. It is to be borne in mind, however, that the question of fundamental interest is always that of how these micro-organisms are able to utilize

the nitrogen which is absorbed in gaseous state. No such power is known among phanerogams. It has not yet been demonstrated to be possible with the lower algae, and certainly none of the interesting results so far obtained indicates that it is a very fundamental character of fungi and bacteria. In this connection, perhaps, it may also be stated that nothing whatever is known concerning the method by which carbon dioxide is chemo-synthetically utilized by the nitrite and nitrate bacteria.

ENGINEERING NOTES.

A new type of steam cargo vessel has been launched in England. The vessel is of 9,000 gross tonnage, and the most notable feature is the absence of masts for carrying rig. Instead, there are four tall pillars in pairs fore and aft, to which the cargo handling derricks are fitted. There are seven holds provided for the stowage of bulky and heavy cargo, and for expeditiously dealing therewith there are twenty-six powerful winches and derricks.

There is in course of construction for the engineering section of the Birmingham University a testing machine of 300 tons maximum capacity, for the testing of whole members of constructional work, such as complete girders, columns, roof-principals, etc. The machine is to be hydraulically operated with the adjustment movements for testing pieces 30 feet in length down to the smallest piece, controlled by an electric motor working at 750 revolutions per minute. This is one of the largest machines of this class that has been constructed and will contain all the latest developments. The whole of the various operations such as the hydraulic power applying the strain, the electric motor for adjusting, and the recording steel-yard, are to be governed from one point.

The first of the new type of coast destroyer for the British navy, the "Cricket," has been launched. This class of small fighting unit possesses several interesting features, the most notable of which is that liquid fuel exclusively is to be employed, while the propelling machinery comprises the Parsons turbines. The vessel is of 230 tons displacement, and the turbine machinery is of 4,000 indicated-horse-power capable of developing a speed of 26 knots per hour. There are two sets of boilers, each of 2,000 horse-power. No stowage for coal is provided, the liquid fuel firing installation being that evolved by the naval department as the result of their continual experiments during the past three years. This vessel will be the first torpedo destroyer to be fitted with this system of firing.

Nickel steel has of late received special attention, and has been investigated by engineers, in relation to its usefulness as a structural material. For many years, metallurgists have experimented on the effect of the addition of special metals to steel with a view of increasing the ultimate strength and elastic limit of the steel without proportionately decreasing its ductility. So far, as a special structural steel, nickel steel is the only one which has proved satisfactory. Nickel steels of varying carbon and nickel have been successfully used during the last fifteen years for marine and stationary engine shafting, locomotive axles, piston rods and crank pins, and a wide variety of forgings and castings for parts of machinery. Its application for the manufacture of armor plate, since 1890, is well known. It has recently been adopted, especially in this country, for gun forgings. It has been proposed for structural work before, but is now actually used for bridge construction in the eye-bars for the Blackwell's Island cantilever bridge across the East River, New York city, and may take an important place as a structural material for long-span bridges.

Carbon steel, the old steel that was in use for generations, was pure iron with a certain varying percentage of carbon in it. A step forward from the carbon is what is called air-hardening, or self-hardening steel. By using certain ingredients with the steel and heating that particular composition or compound to a certain temperature and cooling it, usually in air drafts, the tool would have a toughness, and, what is more, it would not lose its temper. The value of these steels is not in the trueness of their edge, or their strength, or toughness, but it is the temperature at which they work. The old carbon steels had to be worked at a relatively cool temperature, but a self-hardening steel could be worked at a very much higher temperature. Now come what are called the high-speed steels, which when they are being heated for tempering are heated so hot that the surface will actually run, and unless you heat them to about that point you cannot get a good finish temper. In working with high-speed steels the general instructions are not to use them above a red heat. That seems simply absurd to speak about using a cutting tool to red heat. But high-speed steels will actually work until in darkness they will pretty nearly show red. That is where the time is gained. In taking a heavy cut in roughing there is an immense amount of heat generated that must be got rid of. Part of it will go to the tool because the tool is right at the point of generation of the heat all the time. And the advantage of these steels is in their ability to stand the high temperature thus brought about. The new high-speed steel is not considered the best steel for some purposes—a light cut or finishing cut, for example. As good a finished surface cannot be got with high-speed steel as with carbon steel. But wherever metal has to be removed, wherever heat is generated, that is where they have the decided advantage.

TRADE NOTES AND FORMULÆ.

Gold Color Varnish for Metals.—Orange gum lac, 60 grammes; sandarac, 30 grammes; gamboge, 15 grammes.—France Horigère.

Sensitizing of Photographic Drawing Paper.—Photographic prints of extensive landscapes and portraits on a large scale are successfully and artistically made by the use of Whatman paper, which is sensitized as follows:

The whole sheet is first plunged into a bath consisting of 13 parts by weight of pure sodium chloride, 9 parts of ammonium chloride, 0.50 part of potassium bichromate, and 1,000 parts by weight of water. After drying, it is sensitized by holding one side of it for two minutes over a bath of 32 parts of silver azotate, 10 parts of citric acid, and 1,000 parts by weight of water. A strong impression is to be taken in the printing frame. The toning and fixing processes are the same as with other photographic paper.—Moniteur de la Papeterie Française.

To Burnish Copper.—The metal is first to be made perfectly clean, and a paste composed of 1 to 3 parts of English red and 1 part of graphite, thoroughly mixed with spirit diluted with one-half water, is applied with a soft brush; or a mixture of 2 parts of verdigris, 2 parts of cinnabar, 5 parts of ammonium chloride (sal-ammoniac) and 5 parts of alum, finely powdered, ground with spirit or water, and with a little blue vitriol added, may be used.

The metallic object is then heated very hot in an oven, and kept at a high temperature for several hours; after this the dry coating is brushed with soft brushes. The whole process is repeated several times, until the desired brown color is obtained. Finally, a mixture of equal parts of wax and turpentine is applied with a soft brush or with a wad of cotton.—Metallarbeiter.

Specific Weight and Strength of Alloys of Copper and Zinc.—The specific gravity always decreases as the content of zinc increases; in alloys with 70 or 80 per cent of zinc there is a marked compression. The specific weight of alloys which contain larger quantities of zinc is raised by mechanical working and in cooling, but can be lowered again to a large degree by annealing. Some weights of copper and zinc alloys are given below:

Copper.	Zinc.	Specific weight.
100.00	8.890
90.65	8.834
85.34	14.63	8.584
79.51	20.49	8.367
69.98	34.02	8.390
59.28	40.74	8.329
49.23	50.76	8.304
39.27	60.73	8.171
32.66	67.14	8.048
19.52	80.48	7.863
10.82	89.18	7.315
.....	100.00	7.206

The greatest strength is shown in the alloys containing from 20 to 30 per cent of zinc; if the percentage is above 60, the strength is considerably diminished, even to the extent of making the alloy unsuitable for most technical purposes. The hardness of the copper is increased by the addition of zinc, and alloys containing 49.5 to 50 per cent of zinc are harder than with a larger percentage of copper. If the percentage of zinc is higher than this, the alloy becomes so brittle that the degree of hardness cannot be determined. The determination becomes possible again with a percentage of 89.2 of zinc, and the hardness of this alloy is not much less than that of alloys with 49.5 per cent of copper.—Metallarbeiter.

Preparation of Model Powder.—The method of preparing powder for models here to be described has been patented in Germany by Eugen Pinkus, of Berlin. It is intended to offer a substitute for the expensive lycopodium in general use for this purpose, and its basis is starch.

It is extremely difficult to remove all the water from starch in the first place, and, as ordinarily kept, in powdered form, it absorbs moisture again. But for the purpose in question, it is essential to make and keep the starch a perfectly dry powder, as only in this state can it be used for dusting over the models. To effect this, it is mixed with some suitable salt, calcium sulphate, for instance, which has previously been entirely freed from water. The salt not only absorbs the moisture of the starch, but prevents it from absorbing any more.

The calcium sulphate, calcium carbonate, or other suitable salt, is heated in an iron vessel to expel the water. The starch powder is stirred into it, and heated, still stirring, at a temperature not exceeding 160 deg. C. (212 deg. F.) as a higher temperature would change the starch to dextrin. The perfectly dry salt takes in the moisture contained in the starch, and the result is a perfectly dry powder, as fine as flour, excellently well adapted to the uses of modeling. A little lycopodium may be added to the powder, or some of the charcoal powder also in use for the same purpose.

This powder has the advantage over lycopodium that it makes much less dust in using. This is a very troublesome quality of lycopodium, especially on account of the inflammability of the dust.

The proper proportions for the powder are about 50 parts by weight of calcium sulphate to 1,000 of starch, with from 100 to 150 parts of lycopodium or 1,000 of charcoal powder, linden charcoal being the best.—Neueste Erfindungen und Erfahrungen.

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